A. M. A.
ARCHIVES OF
SURGERY

EDITORIAL BOARD

WALTMAN WALTERS, Chairman, Rochester, Minn.
LESTER R. DRAGSTEDT, Chicago
ROBERT ELMAN, St. Louis
ALTON OCHSNER, New Orleans
ARTHUR W. ALLEN, Boston
ALFRED BLALOCK, Baltimore
FRANK HINMAN Jr., San Francisco
G. E. LINDSKOG, New Haven, Conn.
BARNES WOODHALL, Durham, N. C.

RICHARD J. PLUNKETT, M.D., Chicago, Managing Editor

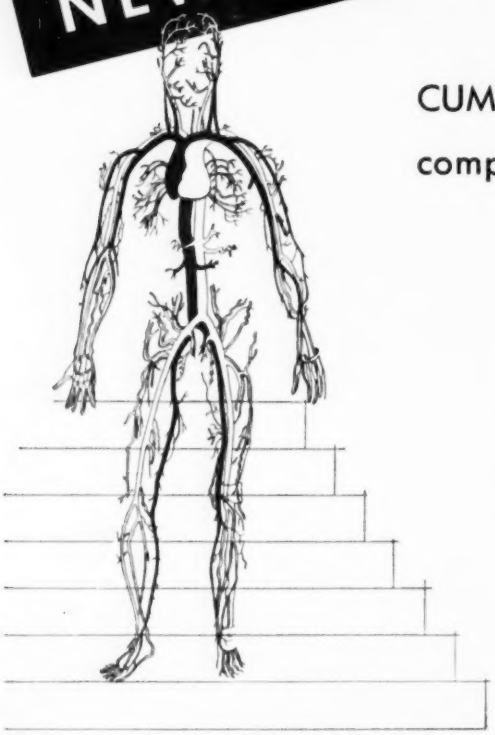
APRIL 1952
VOLUME 64 NUMBER 4

Published Monthly by
AMERICAN MEDICAL ASSOCIATION
535 NORTH DEARBORN STREET • CHICAGO 10, ILLINOIS

Entered as Second Class Matter July 10, 1925, at the Postoffice at Chicago, Under the Act of March 3, 1879. Annual Subscription, $14.00

TABLE OF CONTENTS FIRST PAGE

NEW anticoagulant



CUMOPYRAN...here's how it compares with Dicumarol:

1. Hematuria has not been observed in patients receiving CUMOPYRAN over prolonged periods except in a few instances where over-anticoagulation had occurred.

2. Little or no gastrointestinal disturbance has been encountered with CUMOPYRAN.

3. Certain authors have believed it easier to maintain the desired prothrombin level with CUMOPYRAN.

4. Onset of effect is sometimes more rapid.

5. It is more potent; therefore the dosage is smaller.

6. Patients who are resistant to Dicumarol effect are sometimes less resistant to the action of CUMOPYRAN.

IT IS important that CUMOPYRAN be used with the same precautions recommended for Dicumarol. Before prescribing CUMOPYRAN, please write to Abbott Laboratories, North Chicago, Illinois, for detailed literature describing its use and the precautions to be observed.

CUMOPYRAN is supplied in 25-mg. and 50-mg. grooved tablets in bottles of 100. Abbott

Cumopyran

TRADE MARK

(CYCLOCUMAROL, ABBOTT)

References: **1.** Scheel, L. D. (1949), University of Wisconsin Press, June. **2.** Battle, W. D., Capps, R. T., Orth, O. S., and Meyer, O. O. (1950), J. Lab. & Clin. Med., 35:8, January. **3.** McCarter, J. C., Bingham, J. B., and Meyer, O. O. (1944), Amer. J. Path., 20:651, May. **4.** Meyer, O. O. (1950), Weekly Bul. St. Louis Med. Soc., 44:409, April 14. **5.** Allen, G. W., Hull, E. (1951), New Orleans Med. & Surg. J., 103:323, Feb.

WHEN YOUR CHOICE IS SILK OR COTTON

ETHICON®
Sutures
of course!

high tensile strength permits the use of finer-gauge sutures in virtually every operative procedure. Available in Non-Capillary Silk, Cotton and Nylon, Ethicon textile sutures are easy to manipulate and tie, economical to use — can be re-autoclaved for future use.

ETHICON

ATRALOC® *Needle Sutures*

For the Surgeon...

ATRALOC provides outstanding conveniences:

- minimal tissue trauma — needle carries single strand
- improved points and constant sharpness
- longer, more useful flat area — needle won't turn in holder
- saves time of needle threading
- eliminates unthreading during operation

For the Hospital...

ATRALOC effects appreciable economies:

- minimizes needle inventories — fewer sizes and varieties needed
- saves nurse hours
- simplifies replacement problems
- eliminates needle preparation (cleaning, washing, sharpening)

SPECIAL ADVANTAGES OF ATRALOC SEAMLESS NEEDLES

ATRALOC Seamless Needles are needles of choice for general closure, obstetrics, gynecology and most procedures where catgut is indicated. They have a single temper throughout — optimal flexibility and uniform strength without soft spots or brittleness.

ETHICON
SUTURE LABORATORIES
INCORPORATED

SUTURE LABORATORIES AT NEW BRUNSWICK, N. J., CHICAGO, ILL., SAO PAULO, BRAZIL, SYDNEY, AUSTRALIA, EDINBURGH, SCOTLAND

CONTENTS

Original Articles

Cardiac Arrest
L. Corsan Reid, M.D.; Hugh E. Stephenson Jr., M.D., and J. William Hinton, M.D., New York 409

Major Surgery in Old People
Chester A. Haug, M.D., and W. Andrew Dale, M.D., Rochester, N. Y. 421

Pilonidal Sinus
Richard W. Dwight, M.D., Framingham, Mass. 438

Fractures of the Shaft of the Tibia and Fibula
Earnest B. Carpenter, M.D., Richmond, Va.; John J. Dobbie, M.D., Hagerstown, Md., and Christian F. Siewers, M.D., Fayetteville, N. C. 443

Anterior Herniation of a Ruptured Lumbar Intervertebral Disk
Ralph B. Cloward, M.D., Honolulu, Hawaii 457

Effects upon the Lung of Varying Periods of Temporary Occlusion of the Pulmonary Artery
Harry A. Davis, M.D.; William B. Gordon, M.D.; Edward W. Hayes Jr., M.D., and Malcolm T. Wasley, M.D., Los Angeles 464

Stenosing Tenovaginitis at the Wrist and Fingers
Paul W. Lapidus, M.D., and Richard Fenton, M.D., New York 475

Fractures of the Ankle
N. Lauge-Hansen, M.D., Randers, Denmark 488

Radiohumeral Synovitis
Moore Moore Jr., M.D., Memphis 501

Conservative Treatment of Fractures of the Tibial Plateau
Carl E. Badgley, M.D., and Sylvester J. O'Connor, M.D., Ann Arbor, Mich. 506

Surgical Emergencies Resulting from Corpus Luteum Cysts and Hematomas
Tokuso Taniguchi, M.D.; Jack A. Klieger, M.D., and Michael J. Kuhn, M.D., Milwaukee 516

Case Reports

Cholelithiasis Causing Blood in the Stools
Frank H. Ridgley, M.D., West Chester, Pa. 525

Congenital Intrathoracic Aneurysm of the Vertebral Artery
William H. Muller Jr., M.D.; David Boody, M.D., and William P. Longmire Jr., M.D., Los Angeles 527

Leiomyoma of the Common Bile Duct
Henry Archambault, M.D., and Rene Archambault, M.D., Detroit 531

THE A. M. A. ARCHIVES OF SURGERY is published by the American Medical Association for the advancement of surgery and as a medium of publication for research, clinical observations and experimental work in surgery.

Manuscripts for publication and correspondence relating to the editorial management, to communications, subscriptions, reprints, etc., should be addressed, A. M. A. ARCHIVES OF SURGERY, American Medical Association, 535 North Dearborn Street, Chicago 10.

Articles are accepted for publication on condition that they are contributed solely to the A. M. A. ARCHIVES OF SURGERY. Manuscripts must be typewritten, preferably double spaced, and the original copy should be submitted. Zinc etchings and halftones will be supplied by the Association when the original illustrations warrant reproduction and when their number is not considered excessive.

Footnotes and bibliographies (the latter are used only in exhaustive reviews of the literature) should conform to the style of the *Quarterly Cumulative Index Medicus*. This requires, in the order given: name of author, title of article and name of periodical, with volume, page, month—day of month if the journal appears weekly—and year.

Matter appearing in the A. M. A. ARCHIVES OF SURGERY is covered by copyright, but as a rule no objection will be made to its reproduction in a reputable medical journal if proper credit is given. However, the reproduction for commercial purposes of articles appearing in the A. M. A. ARCHIVES OF SURGERY or in any of the other publications issued by the Association will not be permitted.

The A. M. A. ARCHIVES OF SURGERY is issued monthly. The annual subscription price (for two volumes) is as follows: domestic, $14.00; Canadian, $14.40; foreign, $15.50, including postage. Current single copies are $1.25, postpaid, except special numbers.

Checks, money orders and drafts should be made payable to the American Medical Association.

OTHER PERIODICAL PUBLICATIONS
of the American Medical Association

THE JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION—Weekly. Covers all the medical sciences and matters of general medical interest. Illustrated. Annual subscription price (three volumes): domestic, $15.00; Canadian, $16.50; foreign, $19.00. Single copies, 45 cents.

A. M. A. ARCHIVES OF INTERNAL MEDICINE—Monthly. Devoted to the publication of advanced original clinical and laboratory investigations in internal medicine. Illustrated. Annual subscription price (two volumes): domestic, $10.00; Canadian, $10.40; foreign, $11.00. Single copies, $1.00.

A. M. A. ARCHIVES OF NEUROLOGY AND PSYCHIATRY—Monthly. A medium for the presentation of original articles on nervous and mental diseases, with abstracts from foreign and domestic literature, book reviews, transactions of special societies, etc. Illustrated. Annual subscription price (two volumes): domestic, $12.00; Canadian, $12.40; foreign, $13.50. Single copies, $1.25.

A. M. A. ARCHIVES OF DERMATOLOGY AND SYPHILOLOGY—Monthly. Devoted to advancing the knowledge of and progress in cutaneous diseases and syphilis. Publishes original contributions on these two subjects, transactions of the important dermatological societies, book reviews, etc. Illustrated. Annual subscription price (two volumes): domestic, $12.00; Canadian, $12.40; foreign, $13.50. Single copies, $1.25.

A. M. A. AMERICAN JOURNAL OF DISEASES OF CHILDREN—Monthly. Presents pediatrics as a medical science and as a social problem. Includes carefully prepared reviews, based on recent pediatric literature, abstracts from foreign and domestic literature, book reviews, transactions of special societies, etc. Illustrated. Annual subscription price (two volumes): domestic, $12.00; Canadian, $12.40; foreign, $13.50. Single copies, $1.25.

A. M. A. ARCHIVES OF OPHTHALMOLOGY—Monthly. Includes original articles on diseases of the eye, annual reviews of special subjects, book reviews, transactions of special societies, etc. Illustrated. Annual subscription price (two volumes): domestic, $12.00; Canadian, $12.40; foreign, $13.00. Single copies, $1.25.

A. M. A. ARCHIVES OF OTOLARYNGOLOGY—Monthly. A medium for the presentation of original articles on diseases of the ear, nose and throat, with abstracts from foreign and domestic literature, book reviews, transactions of special societies, etc. Illustrated. Annual subscription price (two volumes): domestic, $12.00; Canadian, $12.40; foreign, $13.00. Single copies, $1.25.

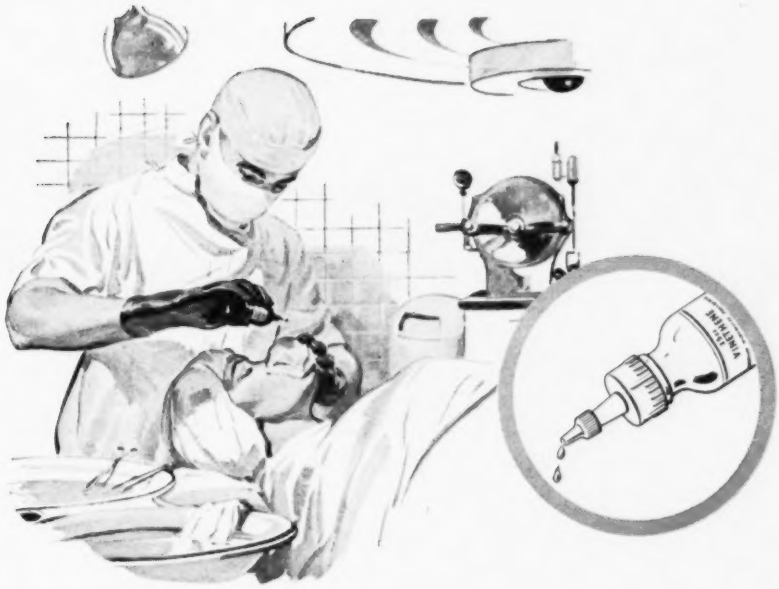
A. M. A. ARCHIVES OF PATHOLOGY—Monthly. A periodical devoted to the publication of original articles and general reviews in the field of pathology. Illustrated. Annual subscription price (two volumes): domestic, $8.00; Canadian, $8.40; foreign, $9.00. Single copies, $1.00, except special issues.

A. M. A. ARCHIVES OF INDUSTRIAL HYGIENE AND OCCUPATIONAL MEDICINE—Monthly. Devoted to the advancement of knowledge of the diseases of industry and to the publication of scientific investigation in this field. Illustrated. Annual subscription price (two volumes): domestic, $8.00; Canadian, $8.40; foreign, $9.00, including postage. Single copies, $1.00.

QUARTERLY CUMULATIVE INDEX MEDICUS—A complete subject and author index to the worth while current medical literature of the world. Issued twice a year. Volumes bound for permanent reference. Subscription price, calendar year: domestic, $20.00; Canadian, $22.00; foreign, $22.00.

AMERICAN MEDICAL ASSOCIATION

535 North Dearborn Street **CHICAGO 10**



To Minimize Emotional Trauma . . .
A Rapid and Bland Induction

VINETHENE®, administered by the simple and convenient open-drop technic, induces anesthesia swiftly and not unpleasantly. Recovery is rapid and the after-effects are minimal.

VINETHENE is a particularly suitable anesthetic:

for inducing anesthesia prior to use of ethyl ether for maintenance . . .
for short operative procedures . . .
for complementing agents such as nitrous oxide and ethylene.

Literature on request.

VINETHENE®

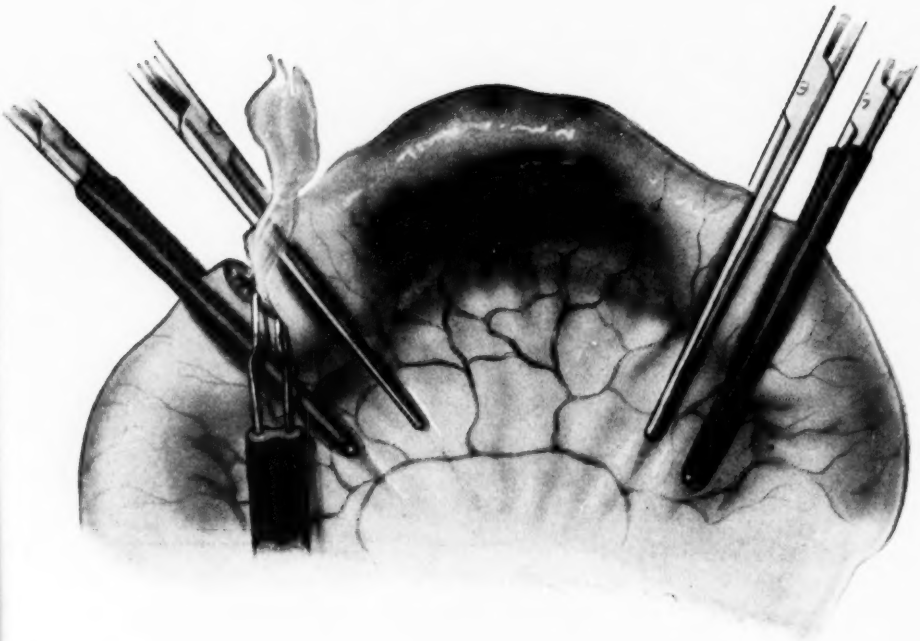
(Vinyl Ether for Anesthesia U. S. P. Merck)

AN INHALATION ANESTHETIC FOR SHORT OPERATIVE PROCEDURES

COUNCIL ACCEPTED

VINETHENE is a registered trade-mark of Merck & Co., Inc.

MERCK & CO., INC.
Manufacturing Chemists
RAHWAY, NEW JERSEY
In Canada: MERCK & CO. Limited—Montreal



in bowel sterilization:

"Terramycin... had a pronounced effect on the bacterial flora of the healthy and diseased bowel of man.... Its effectiveness as an antimicrobial agent in the preparation of patients for surgical measures on the bowel appeared unexcelled."

DiCaprio, J. M., and Rantz, L. A.: Arch. Int. Med. 86:649 (Nov.) 1950.

ANTIBIOTIC DIVISION Pfizer

Terramycin is also indicated in a wide range of

Terramycin

Gram-positive Bacterial Infections

Lobar pneumonia • Mixed bacterial pneumonias
Bacteremia and septicemia
Acute follicular tonsillitis
Septic sore throat • Pharyngitis
Acute and chronic otitis media
Acute bronchitis • Laryngotracheitis
Tracheobronchitis • Sinusitis
Chronic bronchiectasis
Pulmonary infections associated with pancreatic insufficiency
Scarlet fever • Urinary tract infections
Acute and subacute purulent conjunctivitis
Acute catarrhal conjunctivitis
Chronic blepharoconjunctivitis not involving the meibomian gland
Abscesses • Cellulitis
Furunculosis • Impetigo
Infections secondary to Acne vulgaris
Erysipelas • Peritonitis

Gram-negative Bacterial Infections

Gonorrhea • Brucellosis
Bacteremia and septicemia
Friedländer's pneumonia
Mixed bacterial pneumonias
Pertussis • Diffuse bronchopneumonia
Post-partum endometritis • Granuloma inguinale
Dysentery • Urinary tract infections
Respiratory tract infections
Cellulitis • Peritonitis • Tularemia

Spirochetal Infections

Syphilis • Yaws • Vincent's infection

Rickettsial Infections

Epidemic typhus • Murine typhus
Scrub typhus • Rickettsialpox
Q fever • Rocky Mountain spotted fever

Viral Infections

Primary atypical pneumonia (virus pneumonia)
Lymphogranuloma venereum • Trachoma

Protozoal Infections

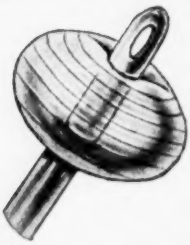
Amebiasis

Available as

CAPSULES
ELIXIR
ORAL DROPS
INTRAVENOUS
OPHTHALMIC OINTMENT
OPHTHALMIC SOLUTION

CHAS. PFIZER & CO., INC., *Brooklyn 6, N. Y.*

BARDEX® BALLOON CATHETERS



THE ACCEPTED STANDARD OF EXCELLENCE

WHEN A HUMAN LIFE MAY BE AT STAKE
THERE CAN BE NO COMPROMISE WITH

Quality

BARD UROLOGICAL INSTRUMENTS

C.R.BARD, Inc., Summit, N.J.

Distributors for
UNITED STATES CATHETER and INSTRUMENT CORP.

THERE IS NO SATISFACTORY SUBSTITUTE FOR QUALITY

A. M. A.
ARCHIVES OF SURGERY

VOLUME 64 APRIL 1952 NUMBER 4

COPYRIGHT, 1952, BY THE AMERICAN MEDICAL ASSOCIATION

CARDIAC ARREST

L. CORSAN REID, M.D.
HUGH E. STEPHENSON Jr., M.D.
AND
J. WILLIAM HINTON, M.D.
NEW YORK

CARDIAC arrest is of infrequent occurrence and fortunately is rarely of such duration as to require surgical intervention. It is always ominous and if persistent is an emergency of the utmost importance to the surgeon. Recently there has been a marked increase in the interest in this condition. This is in part due to the increasing awareness of the derangement and its calamitous potentialities, particularly in the operating room. Several recent articles attest to this.[1] Many of these reports showed indefatigable ingenuity in devising technical procedures to rectify the condition, and in many instances these procedures have been successful. To a mechanistically minded observer, however, there appeared to be a lack of interest in the mechanism of the genesis of cardiac arrest and the possibilities of its prevention. There were some routine generalities regarding development of the condition, but this phase of the problem was left sufficiently vague to allow full attention to be focused on operative procedures.

We are convinced that there is much confusion among surgeons about this subject. It seems in order, therefore, to bring out the mechanism by which cardiac arrest occurs and the precise role of the various contributory factors in its genesis.

There are two principal mechanisms involved in the sudden failure of the heart to maintain the circulation: (1) ventricular fibrillation, which is outside the scope of this paper and is very rare in comparison to (2) cardiac arrest, which is by all odds the commonest. It is not too much to say that the vast majority of cases of cardiac arrest, if indeed not all, which require surgical intervention and in which one

From the Department of Surgery, The Post-Graduate Medical School of New York University.

1. (*a*) Morland, A.: Pleural Shock, Lancet **2**:1021-1023 (Dec. 3) 1949. (*b*) Breitwieser, E. R.: Electrocardiographic Observations in Chronic Cholecystitis Before and After Surgery, Am. J. M. Sc. **213**:598-602 (May) 1947. (*c*) Hodge, G. B.; Messer, A. L., and Hill, H.: Effect of Distention of the Biliary Tract on the Electrocardiogram, Arch. Surg. **55**:710 (Dec.) 1947. (*d*) Freeman, A. G.: Electrocardiographic Finding During Operative Manipulations of the Viscera and Vagus Nerves, Lancet **1**:926-930 (April) 1951. (*e*) Carotid Sinus Syndrome, editorial, J. A. M. A. **143**:656 (June 17) 1950. (*f*) Lahey, F. H., and Ruzicka, E. R.: Experiences with Cardiac Arrest, Surg., Gynec. & Obst. **90**:108-118 (Jan.) 1950. (*g*) Reid, L. C.: Practical Considerations in the Surgical Management of Children with Regard to the Autonomic Nervous System, New York J. Med. **50**:2937-2939 (Dec. 15) 1950. (*h*) Brown, E. B., and Miller, F. A.: Cardiac Arrest in Dogs Following a Rapid Fall in Alveolar Carbon Dioxide Tension, Fed. Proc. **10**:20 (March) 1951; (*i*) Treatment of Cardiac Arrest, Veterans Admin. Tech. Bull. **4**:10-65 (July 18) 1950.

can hope for or even anticipate a successful result, could be completely prevented by atropine, a simple, safe, and reliable therapeutic agent of long-established reputation.

The clear-cut demonstration of the reflex nature of the derangements in cardiac dynamics following mechanical irritation of the mucosa of the respiratory or gastrointestinal tracts by a wide variety of contrivances, such as intratracheal tubes and catheters, bronchoscopes, gastroscopes, esophagoscopes, inflation of cuffs, etc., or even spraying of the throat with water, was shown by the electrocardiograph.[2] In order to have a sound understanding of the precise steps taking place in this mechanism, it will be helpful to review some of the anatomy of the structures involved as well as their fundamental physiology.

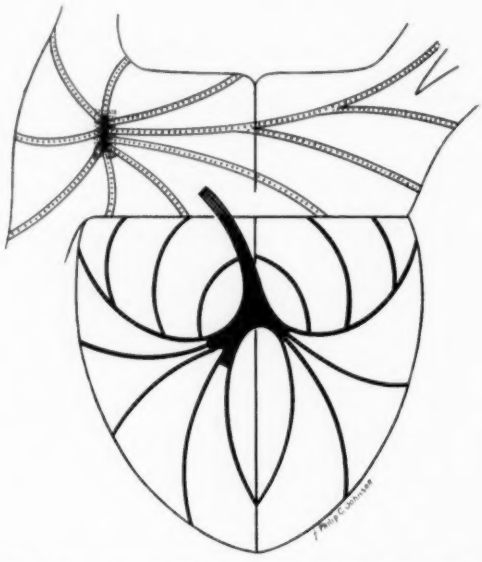


Fig. 1.—Dark lines show specific tissue and dotted lines vagal branches.

THE SPECIFIC TISSUE

At the meeting of the American Medical Association in Atlantic City, N. J., in 1951, a paper was read in which it was stated that there was no specific tissue in the heart.[3] The other extreme is demonstrated by the fact that once in every few years someone announces the discovery of a new area with specific-tissue characteristics. It seems pertinent, then, to inquire what is the specific tissue? The fibers composing the specific tissue are generally, somewhat different morphologically from those of the common myocardium, although one can find fibers of exactly the same structure, as determined by present methods, which are not

2. Reid, L. C., and Brace, D. E.: Irritation of the Respiratory Tract and Its Reflex Effect upon the Heart, Surg., Gynec. & Obst. **70**:157 (Feb.) 1940.

3. Glomset, D. J.: Cardiac Conduction, Program of the 100th Annual Session of the American Medical Association, Scientific Assembly, Atlantic City, June 11-15, 1951, p. 69.

specific tissue. There is no absolutely reliable anatomically distinguishing feature, and therefore some other criteria must be used for differentiation. This, of course, is the capacity to form stimuli independently and autonomously. This capacity for automaticity is the outstanding feature of the specific tissue. Every one of the millions of specific-tissue fibers is able to form a stimulus. The rhythmic formation of these stimuli, generally speaking, decreases from above downward in rate; in the highest areas of the sinus node the rate is about 80 to 90 per minute, while deep in the ventricle it may fall to 10 per minute. This neuromuscular (and more muscular than "neuro") tissue expresses its automaticity by rhythmical contractions. It is the hardiest tissue in the body and can function for long periods without oxygen or even blood supply. This point is of crucial importance when one comes to discuss the role of anoxia. The specific tissue is susceptible of revival to good function as long as 72 hours after death. One other point which might be mentioned is the law of auxomeric conduction, which states that as long as there is one healthy fiber present then conduction will be normal. Clinically this means that one can have widespread disease in the specific tissue which under ordinary conditions could readily escape detection. The distribution of the vagus in the specific tissue is restricted to the auricles. There are no vagal fibers in the mammalian ventricles. Further details of this structure are illustrated in Figure 1.

REFLEX PATHWAYS

The pathway by which a reflex can travel to the heart from those areas of our present interest, such as the respiratory passages and the gastrointestinal mucosa, may take any one of three routes: first, over the vagal network to the vagal center and from there by an efferent path to the heart; second, by an axon reflex in the vagal system by passing from one branch to another without going centrally,[4] and third, by irradiation of vagal impulses in which the stimulus originates at vagal nerve endings and passes to a ganglion where it transfers to a branch of the sympathetic system and then to the heart (Fig. 7).

The areas in which these impulses can originate are wherever there are vagal nerve endings. According to Larsell,[5] there are three groups of nerve plexuses with wide distribution in the lung: (1) the bronchial group; (2) the vascular group; and (3) the pleural group.

In the bronchial group, which includes the trachea and nasopharynx, the trigger stimulus appears most commonly to be an intratracheal tube, inflation of a cuff, or a bronchoscope. In the vascular group the trigger stimulus seems to be the stretching of the vessel wall by the presence of an embolism, the commonest clinical expression of which is the so-called pulmocoronary reflex so well described by Scherf.[6] The mechanism of the initiation of this reflex may well be the stretching of the wall and inadequate clearing of accumulated metabolites; the metabolites,

4. Carlson, A. J., and Luckhardt, A. B., cited by Schweitzer, A.: Die Irradiation autonomer Reflex, Basel, S. Karger, 1937, p. 203.

5. Larsell, O.: The Ganglia Plexuses and Nerve Terminations in Mammalian Lung and Pleura, J. Comp. Neurol. **35**:97, 1922-23.

6. Scherf, D., and Schönbrunner, E.: Über Herzbefunde bei Lungenembolien, Ztschr. f. klin. Med. **128**:455, 1935; Über den Pulmocoronaren Reflex bei Lungenembolien, Klin. Wchnschr. **105**:340, 1937.

acting on local nerve endings, set up an impulse.[7] This theory, of course, is speculative; however, the existence of the reflex is reasonably well established, and certainly simple occlusion of the pulmonary vessel is a harmless affair except for the subsequent changes locally. It is well known that ligation of the pulmonary artery is not a serious procedure. In animals the occlusion of small vessels with foreign body emboli is frequently accompanied with dyspnea and even bronchial spasm. These effects disappear immediately on vagal section. Incidentally, the electrocardiogram in pulmonary embolism is often indistinguishable from that seen in coronary thrombosis, particularly if the latter involves many small branches. In this connection it might be mentioned that a reflex mechanism may well be involved in the death of persons taken from the water in whom no water is found in the lungs. In cases in which the reflex is set up by a stimulus originating in the branches of the pulmonary artery, the effects are manifest on the coronary circula-

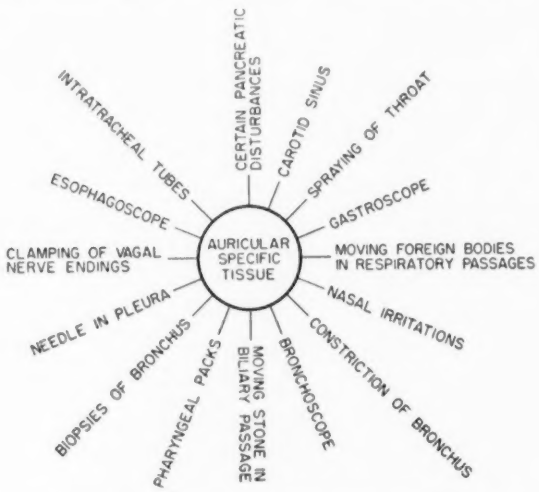


Fig. 2.—Potential sources of reflexes which could affect the specific tissue.

tion, which, as is well known, is constricted by vagal stimulation. The small percentage of cases in which electrocardiographic changes are observed in pulmonary embolism depends in part at least on the fact that the vagal control of the coronary circulation is not very efficient. It might, of course, be more complete in some cases than in others. This might well explain why some patients in whom there is myocardial necrosis without any evidence of coronary artery disease are relieved of their pain by administration of nitroglycerin.[8] Those impulses originating in the pleura from scratching with a needle or any other form of mechanical irritation travel over a pathway which carries them to the specific tissue. On the basis of present knowledge, one might well conclude that reflexes having their trigger stimulus in the mucosa of the respiratory or gastrointestinal tracts as well as in the

7. Reid, L. C., and Brace, D. E.: Reflexes from the Mouth, Trachea and Esophagus Which Stimulate Respiration, Anesthesiology **4**:345, 1943.

8. Buechner, F.: Die Koronarinsuffizienz, Dresden, Theodore Steinkopff, 1939.

pleura have their effects intermediated through the specific tissue. Those originating from the stretching of the pulmonary vessels are mediated by acting on the coronary circulation. It is of the utmost importance for surgeons to realize that the type of stimulus alone can determine the effector organ to which it will go. For example, if a certain frequency of an electrical stimulus is applied to the vagus nerve in the neck, one will see marked bradycardia, minimal gastric secretion, and little bronchial spasm. When the frequency is changed, one may see large gastric secretion high in acid and rich in enzymes with minimal cardiac slowing. When the frequency is changed again, severe bronchial spasm can be seen without significant changes otherwise. More precisely, if one stimulates the central end of the vagus in a dog with a current of frequency of 50 per second, the result is apnea. If the frequency is 10 per second, dyspnea results.[9] One must consider, then, besides the actual anatomical pathways, the type of trigger stimulus to understand

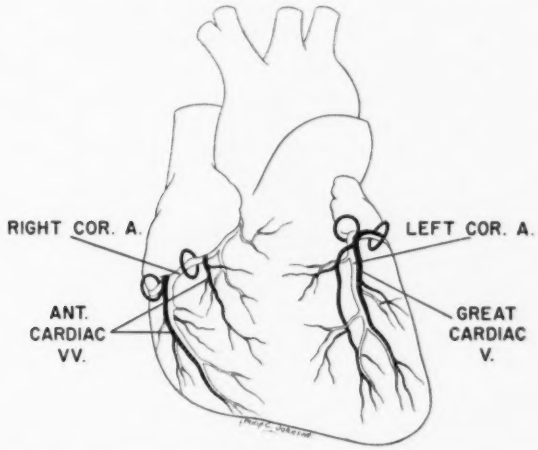


Fig. 3.—Circles indicate pulmonary emboli (especially small ones involving multiple vessels).

the course of the resulting impulse, and this will serve in some measure to explain the almost bewildering complexity in the functional expression of reflexes occurring in the autonomic nervous system (Figs. 2 and 3).

THE ROLE OF ANESTHESIA

The action of anesthesia from such agents as chloroform, ether, cyclopropane, ethylene, and nitrous oxide can best be appreciated by recalling what happens under normal conditions and comparing this with what occurs when morphological lesions are present in the specific tissue with loss of functioning elements. One might well ask the question, if there are no vagal fibers in the ventricle: "How can one get cardiac arrest from vagal stimulation?" The point is that no healthy normal heart can ever stop from vagal stimulation in the sense that serious symptoms will arise. One will never see a carotid-sinus syndrome in a healthy heart. If the heart has

9. Hammouda, M., and Wilson, W. H.: The Presence in the Vagus of Fibers Transmitting Impulses Augmenting the Frequency of Respiration, J. Physiol. **83**:292, 1935.

been the site of disease in which the specific tissue in the ventricles has widespread areas of destruction and if, under these conditions, vagal stimulation depresses stimulus formation in the auricles, the automaticity of the specific tissue in the ventricles will have been abolished and a contraction does not occur or occurs with insufficient rapidity to provide an adequate circulation. Anesthetic agents have precisely a similar action on the functional response of the specific tissue, and it behaves as though there were widespread areas of nonfunctioning tissue. In other words,

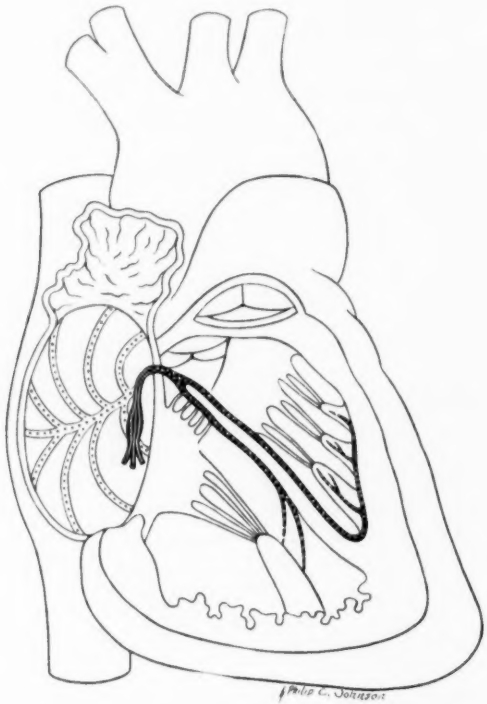


Fig. 4.—Dark lines indicate specific tissue, dotted lines vagal branches, and white specks anesthesia or lesions.

a heart under anesthesia is as vulnerable to vagal stimulation as a heart with diffuse organic lesions would be without anesthesia (Fig. 4).

ROLE OF ANOXIA

The role of anoxia in the causal genesis of these reflexes is of the greatest importance, but it cannot be insisted on too much or too strongly that anoxia per se does not cause a sudden cardiac standstill; rather it produces a change in rate, with tachycardia, a pulse of poor quality, and, if persistent, a gradual slowing and stopping of the heart beat. This is very different from the sudden dramatic cardiac arrest. As we have seen, the specific tissue has the best capacity for activity of any tissue in the body without oxygen. The bradycardia or irregularities which may

precede the cardiac arrest are frequently missed in clinical observation but are obvious in the electrocardiogram. The precise role of anoxia appears to be that while it alone cannot cause a vagovagal reflex nevertheless it potentiates the action of the anesthetic agent so that the net result is further decrease in the capacity of the specific tissue to form stimuli. In a high percentage of dogs vagovagal reflexes can be elicited by mechanical irritation in the trachea or esophagus when the animal is breathing 100% pure oxygen. The trigger stimulus is mechanical irritation to vagal nerve endings with afferent pathways and by an almost endless variety of agents and procedures.

ROLE OF VITAMIN B GROUP

In spite of the fact that there has been a most unfortunate exploitation of the use of vitamins, one should not lose sight of the fact that carelessness about their use is at the opposite end of the scale. The B complex is well known to be important, but in some ways it is unique. It is necessary for growth and well-being earlier in phylogeny than any other vitamin.[10] It is as essential for frogs and insects as it is for birds and mammals and is required as far down the evolutionary scale as the lowly flour beetle. When one is concerned with a tissue as old phylogenetically as the conduction system, which represents the vestigial remnants of the most primitive vascular tube, it seems entirely possible that the B complex may play a more fundamental role in the cell-energy mechanisms of the specific tissue than may seem possible at first sight.[11] Many authors long ago described electrocardiographic changes from vitamin B deficiency, and there has been much supporting evidence since, especially from studies on returning prisoners of war. It would seem to be using ordinary prudence, therefore, to see that an adequate supply of vitamin B is given in any nutritional problem in which specific tissue is going to be subjected to the strain of anesthesia on which might be superimposed the hazard of a vagovagal reflex initiated by some procedure essential in the operative technique. One cannot tell the surgeon not to tie this or irritate that or to be careful of vagal nerve endings or avoid placing tubes in the trachea or even not to use cyclopropane since it is such a powerful parasympathomimetic agent. However, one can say that by the use of procedures now known to be practically 100% effective it is possible to prevent any serious disturbance regardless of what the surgeon does to vagal nerve endings.

THE ROLE OF ENDOCRINE IMBALANCE

To see the role of endocrine imbalance in perspective it is necessary to consider the menopause in women. The subject of similar changes in men is such a controversial one that no conclusions can be drawn. It does not take much experience to observe sighing respiration in men as well as in women, but it is certainly commoner in the latter. It has been known for a long time that the climacteric is associated with symptoms related to the heart, and if there is organic heart disease the symptoms are accentuated at this time and improve when the imbalance has adjusted itself. These observations received little attention until Scherf[12] showed clearly

10. Vitamins: A Survey of Present Knowledge, Medical Research Council Reports, London, 1932, p. 129.

11. Reid, L. C.: Anesthesia in Relation to Cardiac Disease, Anesthesiology **2**:161, 1941.

12. Scherf, D.: The Respiratory and Circulatory Systems in Females with Ovarian Dysfunction, Ann. Int. Med. **13**:1414-1430 (Feb.) 1940.

that the electrocardiographic changes, the symptoms, and the respiratory difficulties were all susceptible of reversal by the use of adequate substitution therapy. Therefore, any operative procedures contemplated at the time of the menopause or during other periods of endocrine imbalance should be covered by appropriate measures. Even if this should be considered excessively cautious, it cannot have other than a salutary effect on cardiac dynamics specifically and on the endocrine imbalance in general.

REPRESENTATIVE CASES

In an unselected series of 35 cases in which a wide variety of anesthetic agents and trigger stimuli were used, there were 10 which showed unmistakable evidence of functional derangements in the specific tissue.[2] At the Lahey Clinic in the last seven years there have been 14 cases of cardiac arrest of such severity as to require surgical intervention.[1f] These represent the extreme cases resulting from some anomaly of the distribution of specific tissue or from unrecognized organic disease or unknown factors which caused ultimate cardiac arrest. There must have been many other cases in which the reaction was milder but which nevertheless represent examples of a vagovagal reflex.

In Figures 5, 6, and 7 three typical cases are shown in which there were three different anesthetic agents with three different responses to mechanical irritation.

Fig. 5.—Prolonged conduction time, sinus inhibition, and escape beat during cuff inflation (lead II; cyclopropane). To the left of the white line is the control with the tube in place.

Two recent cases illustrate in a pointed and convincing fashion that these reflexes are potentially pernicious.

Case 1.—A 6-year-old boy was discovered by his family physician to have a heart murmur. All other findings were normal except for some adenoid tissue. The electrocardiogram was normal. The roentgenogram of the chest was negative, and the heart size was within normal limits. A recommendation was made that the adenoid tissue be removed, with the assurance that it was a minor procedure and that the child could be taken home in the early afternoon if the operation were done in the morning. The patient was admitted to the hospital and was given scopolamine at 7:30 a. m. Anesthesia was started at 9:15 a. m. and adenoidectomy performed at 9:35 a. m. There was some difficulty with bleeding during the time there was considerable mechanical irritation in the nasopharynx with sponges, etc., at which time the pulse was irregular and feeble and respiration was unsatisfactory. Finally the nasopharynx was packed, and after this there was a complete cardiac arrest. Intracardiac injection of epinephrine was carried out without any result, and after an appreciable period during which there was no evidence of returning heart action the thorax was opened. The heart was massaged, and beats commenced promptly, and soon there was a satisfactory action. The decision was made to return the child to his room, but before this was done the nasopharynx was inspected and care was taken to see that the pack was tight. Cardiac arrest again occurred. After procedures such as shaking the child and massaging the chest, the heart commenced beating and rapidly resumed normal action, with good blood pressure readings. The child was returned to the room. The following morning, after an uneventful night, a careful check revealed no unusual findings and he was taken to the operating room for removal of the pack. It was quickly noted that any mechanical stimulations to the nasopharynx gave rise to a poor pulse and actual transient cardiac arrest. It was apparent

that cardiac arrest occurred only when the nasopharynx was disturbed. Because of this the pack was not removed, and the child was returned to his room. A discussion took place in the hospital, and it was suggested by some of the younger physicians that an unusual type of vagovagal reflex might be present and that the child should be given atropine. This was objected to on the grounds that it would make the heart go too fast, which is certainly less undesirable than the fact that it would not go at all. However, on the third day, all other conditions being the same, the child was given atropine just before the nasopharynx was disturbed. The pack was then removed, and careful inspection and various types of mechanical irritation produced no signs of recognizable circulatory or respiratory disturbance. This is an unusual case to be sure, but

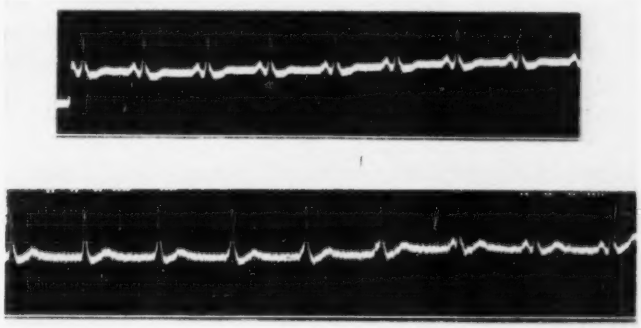


Fig. 6.—Upper picture is the control. Lower tracing taken during insertion of the intratracheal tube, with immediate auricular-ventricular rhythm. (Lead II; nitrous oxide, oxygen, ether.)

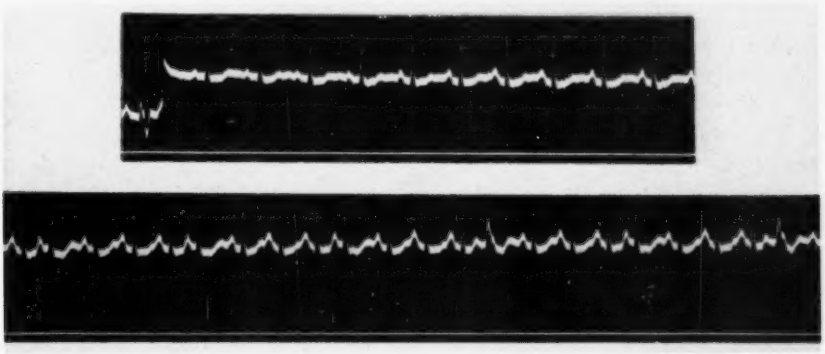


Fig. 7.—Upper tracing shows control. Lower tracing shows tachycardia and auricular extrasystoles during insertion of the tube. This is an irradiation effect. (Lead II; nitrous oxide and oxygen.)

then in every case in which surgical intervention is necessary for cardiac arrest there is some unusual factor.

Case 2.—A young woman underwent an elective herniotomy. When the depth of anesthesia was satisfactory, the laryngoscope was introduced and an intratracheal tube was inserted. On removal of the laryngoscope there was cardiac arrest and subsequent death. Such accidents have happened a sufficient number of times in this institution so that there is a standing rule to administer atropine before intubation. In this case atropine was unfortunately omitted. Other typical cases have been described.[2]

COMMENT

Hodge [1c] failed to show any electrocardiographic changes on distention of the gall bladder or the biliary passages. No changes should be anticipated by pressure alone. On introduction of the tracheal catheter, results only occurred during the movement of the tube or the actual blowing up of the cuff.[2] When the tubes were in place and at rest, no changes were observed. In another paper [1d] the author states that with cyclopropane manipulation of the esophagus the gastric branches of the vagus should be avoided as much as possible. These suggestions might be difficult to follow in many circumstances and are unnecessary besides as there are more efficient ways of preventing undesirable effects. The same author also states that cyclopropane stimulates the vagus. This is hardly a modern viewpoint in the field of pharmacology. Cyclopropane does not stimulate the vagus, but is itself a drug or agent whose action mimics that of acetylcholine, the mediator of vagal nerve action.[13] Some of the cases reported [1f] fall within this vagovagal group. For example, in one case the statement was made: "When a suction catheter was introduced into the trachea by way of an endotracheal tube, cardiac arrest suddenly occurred." Here the mechanical irritation of the new tube acted as a trigger stimulus for initiating the reflex when the ventricular specific tissue was depressed from the anesthetic agent. Atropine would have prevented this occurrence. In another case it was reported: "Cardiac arrest suddenly occurred when the right gastric artery was clamped." Here the trigger stimulus was the clamp. This instance of cardiac arrest also could have been prevented by the use of atropine. The authors make the statement that "these cases will continue to occur." Of course they will if surgeons do not give more attention to their cause and realize that the vast majority can be prevented by the use of a simple tried and tested agent like atropine. In another paper,[1a] in a discussion of pleural irritation and certain disturbances, there is no suggestion that the symptomatology can be explained on a reflex basis and, what is vastly more important, is preventable.

Morphine has a parasympathomimetic action, and accordingly these reflexes are more likely to arise after its administration. This, considering its extensive use as a preoperative drug, makes the giving of atropine that much more essential. Scopolamine is much less effective.

Recent work with acetylcholine clarifies some paradoxical reactions which characterize the action of this substance. A few remarks along this line will illuminate for the surgeon the almost labyrinthine complexity underlying the results of vagal stimulation. Feldberg [14] has shown that acetylcholine is produced by the gut in all coats except the submucosa and independently of nerve supply. Also, acetylcholine is abundant in the placenta and is present in trypanosomes. There is excellent evidence to suggest that the myocardium produces acetylcholine and that a certain level or concentration is essential for its normal activity.[15] Under certain conditions

13. Comroe, J. H., Jr.: The Mode of Action of Drugs upon the Autonomic Nervous System, Veterans Admin. Tech. Bull. T. B., pp. 1-7, 10-52, May 16, 1949.

14. Feldberg, W., and Lin, R. C. Y.: Synthesis of Acetylcholine in Wall of Digestive Tract, J. Physiol. **111**:96-118 (April 15) 1950.

15. Burn, J. H.: A Discussion on the Local Action of Hormones, Proc. Roy. Soc. Ser. B, **137**:281-317 (Oct. 31) 1950.

acetylcholine depresses and under others it stimulates. Bülbring and Burn [16] have recently shown that if a heart is perfused with Tyrode's solution and oxygen it will gradually stop beating at the end of 24 to 36 hours; if acetylcholine is then added to the bath the heart immediately starts to beat, and if a little more is added it will beat still more vigorously. After the beat is well established, the addition of acetylcholine then inhibits it. If acetylcholine is added to the newly beating heart, it causes inhibition. The same is true of extracts made from these hearts in their ability to synthesize acetylcholine. This information assists one in understanding such clinical conditions as ventricular fibrillation on the one hand and cardiac arrest on the other. Scherf's recent demonstration of rapid stimulus formation with aconitine [17] or injury may well depend on similar considerations. The ventricular fibrillation resulting from handling of the heart also falls into this scheme.

There are many references in the older literature, as well as in the new, to the many factors reflexly affecting the heart.[18]

Role of Atropine.—In a broad general way it is reasonable to assume that all vagal activity is the result of the release of acetylcholine from nerve endings and the diffusion of this substance to or on the effector organ is the mechanism by which the break in protoplasmic continuity between nerve and organ is bridged.[19] This acetylcholine is adsorbed on a very small area of the cell surface, and this active patch may well be described as a patterned cell receptor. Atropine blocks the action of acetylcholine without interfering with its release at the nerve ending. This occurs because of the fact that atropine becomes adsorbed on this patterned cell receptor and acetylcholine is unable to locate in the cell area where an effect can take place. This postulated mechanism [20] is most useful and is of acceptable validity at the moment. Atropine has its maximum effect in about 15 to 20 minutes and has adequate action for 45 minutes, with probably sufficient protection for 90 minutes. Other agents such as banthine may supplant atropine because of their longer-lasting action. The mechanism is the same. Atropine will minimize or actually prevent the undesirable reactions potentially present in autonomic reflexes. Atropine is an excellent agent for minimizing the likelihood of ventricular fibrillation.[21]

SUMMARY

The specific tissue has the capacity to originate stimuli and is widely distributed throughout the auricles and ventricles. There are no vagal fibers in the ventricles. In a normal healthy heart no stimulus from any source, including the carotid sinus,

16. Bülbring, E., and Burn, J. H.: Action of Acetylcholine on Rabbit Auricles in Relation to Acetylcholine Synthesis, J. Physiol. **108**:508-524 (June 15) 1949.

17. Scherf, D.; Romano, F. J., and Terranova, R.: Experimental Studies on Auricular Flutter and Auricular Fibrillation, Am. Heart J. **36**:241-251 (Aug.) 1948.

18. Scherf, D., and Boyd, L. J.: Cardiovascular Diseases, London, William Heinemann, 1948, p. 110.

19. Loewi, O.: Chemical Transmission of Nerve Impulses, Sc. Progress **4**:98-119 (April) 1945.

20. Clark, A. J.: General Pharmacology in Heffter, W., and Schüller, editors: Handbuch der experimentellen Pharmakologie, Berlin, Springer-Verlag, 1937, Vol. 4, p. 22.

21. Scherf, D., and Chick, F. B.: Abnormal Cardiac Rhythms Caused by Acetylcholine, Circulation **3**:764-769, 1951.

can cause a general collapse, because the specific tissue in the ventricles, being free of vagal influences, can form stimuli and function autonomously and, as far as the circulation is concerned, in a perfectly satisfactory fashion.

These undesirable reflexes may originate in the mucosa of the respiratory or gastrointestinal tracts and carry out their effects through the specific tissue. Those from the pleura also act on the specific tissue. Those from the pulmonary vessels act on the coronary vessels.

Anesthesia depresses the capacity of the specific tissue to form stimuli, and it responds to vagal stimulation as if there were widespread lesions with nonfunctioning elements. In other words, a heart under anesthesia is as vulnerable to vagal stimulation as a heart with widespread organic disease in the specific tissue would be without anesthesia.

Anoxia per se will not cause or initiate these reflexes, but its presence enormously potentiates the action of the anesthetic agent, with a still further depression of the capacity of the specific tissue to form stimuli.

Vitamin B complex is unusually important for smooth cardiac function, and in any state of deficient nutrition its adequate use preoperatively is most valuable.

During any endocrine imbalance, such as in the climacteric, substitution therapy is a good preoperative measure, and if there is any disturbance in cardiac dynamics such therapy is essential.

The conclusion is inescapable that such procedures as the introduction of various mechanical contrivances into the respiratory or gastrointestinal passages and the clamping or tying of structures containing vagal nerve endings are not without danger, and all such contemplated procedures should be covered by the previous use of atropine. Indeed, it is safe to say that in any case in which the surgeon successfully restores cardiac activity after a cardiac arrest, with the possible exception of ventricular fibrillation, the standstill was due to a sudden depression in the automaticity of the specific tissue following a reflex stimulus and almost certainly was preventable.

24 Normandy Terrace, Bronxville, N. Y.

MAJOR SURGERY IN OLD PEOPLE

CHESTER A. HAUG, M.D.
AND
W. ANDREW DALE, M.D.
ROCHESTER, N. Y.

AS THE older age group of the population increases, the problem of surgery for these patients has become increasingly important. It is generally recognized that operations entail a greater risk in old persons than in younger ones, but there is probably general overestimation of risk and underestimation of what can be done to and for the elderly patient.

Review of the experience of others indicates this greater risk and also that emergency surgery is not tolerated as well as elective operations. Table 1 summarizes some of the recently reported mortality rates in geriatric surgery. It is unwarranted to attempt absolute comparison of mortality statistics for several reasons. Many of the series are too small for accurate statistical comparison. Varied criteria have been used in different reports to differentiate old patients. Mortality varies with surgical indications. Obviously, if many patients are refused surgical treatment because of the grave risk involved, they are not included in the figures for surgical mortality. As a corollary, acceptance of many critically ill patients inevitably increases surgical mortality.

Since the inception of the surgical service of the University of Rochester Hospitals 26 years ago, the incidence of operations in patients beyond 60 years of age has steadily increased, paralleling general experience. Interest in surgery in the older age group has been stimulated and maintained by Dr. John J. Morton,[1] Professor of Surgery, during these years. Our interest in this subject led to a study of results during the past year, since these should show what recent experience here has been. This consecutive series consists of 354 major operations in 313 patients during the one-year period from July 1, 1950, to July 1, 1951. No major general surgical operative cases were omitted. A major operation was defined as one entailing definite hazard to life or function. Only operations performed by members of the general surgical service were considered, and thereby many major operations performed by members of the subspecialty staffs were excluded. This selection insured that the general plan of management was essentially alike. Further assurance of this is the fact that 58% of the entire group was operated on by or intimately known to one of us.

From the Department of Surgery, the University of Rochester School of Medicine and Dentistry.

1. Morton, J. J.: Surgical Care of Patients in the Extremes of Life, Am. J. Surg. **30**:92 (Oct.) 1935.

CLINICAL MANAGEMENT

With proper preoperative preparation and postoperative care, the risks of surgery can be greatly reduced. This is extremely important in old persons who lack the reserves of youth. Prevention of complications must be strongly emphasized. Early active treatment of complications that do occur is necessary to prevent a vicious cycle of events, each further reducing function in vital systems. Old persons cannot be operated on without prior preparation or be allowed to convalesce undisturbed if prohibitive mortality is to be avoided. Continual care and alertness to their needs are necessary.

Preoperatively, the vital functional systems as well as the individual patient as a whole are evaluated clinically and by laboratory tests. It is necessary not only to judge what a given patient is likely to tolerate but also to select the best time to

TABLE 1.—*Comparison of Recent Mortality Statistics in Geriatric Surgery*

Author	Years	Minimal Age	Number of Cases	Type of Operations	Mortality, %		
					Elective, %	Emergency	Over-All
Clagett *	1939-40	65	1,364	Major	....	37.0	9.0
Parsons and Purks †	1942-48	60	322	Major	5.0	12.5	9.0
Welch ‡	1943-47	70	140	Abdominal	13.8	39.0	20.7
Estes §	1943-48	60	400	Major	5.0	16.4	6.5
Carp ‖	1945-49	60	205	Major	....	39.0	17.3
Childs and Mason ¶	1947-49	70	99	Major	....	....	17.2
Strenger #	1939-46	60	82	Hernia	1.6	40.0	10.9
Quigley **	-1940	65	100	Hernia	....	....	1.0
Tanner ††	1936-43	60	20	Gastrectomy	....	....	15.0
			16	Perforated ulcer	....	63.0	....
			20	Gastro-enterostomy	....	....	20.0
Cutler ‡‡	1940-47	60	34	Biliary	....	62.0	....
			65	Amputation	....	38.0	....
			52	Intestinal obstruction	....	55.0	....
This series	1950-51	60	354	Major	5.7	21.9	9.0
			57	Biliary	2.3	0	1.8
			33	Amputation	20.0	33.0	21.0
			44	Inguinal hernia	0	20.0	2.3

* Clagett, O. T.: Minnesota Med. **26:** 884 (Oct.) 1943.
† Parsons, W. H., and Purks, W. K.: Arch. Surg. **58:** 888 (June) 1949.
‡ Welch, C. S.: New England J. Med. **238:** 821 (June 10) 1948.
§ Estes, W. L., Jr.: Pennsylvania M. J. **52:** 937 (June) 1949.
‖ Carp, L.: Brit. M. J. **2:** 1198 (Nov. 25) 1950.
¶ Childs, P., and Mason, S. A.: Brit. M. J. **2:** 1389 (Dec. 17) 1949.
# Strenger, G.: Ann. Surg. **129:** 238 (Feb.) 1949.
** Quigley, T. B.: New Englalnd J. Med. **222:** 666 (April 18) 1940.
†† Tanner, N. C.: Brit. M. J. **1:** 563 (May 8) 1943.
‡‡ Cutler, C. W., Jr.: Ann. Surg. **126:** 763 (Nov.) 1947.

carry out the procedure. Even the sickest patients withstand emergency surgery better if it is delayed long enough for proper preoperative fluid, electrolyte and blood replacement, digitalization, diabetic control, gastrointestinal intubation, and other measures which improve the general condition. One to several hours are well spent in this preparation although excessive delay beyond the point of improvement must be avoided.

In elective cases, observation of the hospitalized patient usually adds much information to the physical examination and the laboratory tests. Inquiry as to recent activity as well as observation of activity in the ward leads to practical information about the total reserve capacity. Some patients have been observed as they climbed stairs as a practical measure of functional status.

Particular importance is attached to treatment of malnutrition and depleted blood volume, sometimes called chronic shock.[2] A program of feeding, administration of vitamins, and multiple blood transfusions is indicated. The oral route of feeding is superior to any parenteral method. Consequently, when feasible, high caloric, high-protein diets are urged on all elderly patients for a period prior to any elective major operation. If a depletion of blood volume is suspected, as evidenced by bodily wasting and subnormal hemoglobin and hematocrit levels, daily transfusions of 250 to 500 cc. of whole blood are administered until the hemoglobin reaches a normal level. During the postoperative period oral alimentation is permitted early. Intestinal tubes are removed early. Complete bed rest should be prevented if possible. Rapid physical and emotional deterioration may result from this. Daily periods of walking must be insisted upon.

All functional derangements which can be treated should be cared for appropriately. Diabetic control, digitalization, eradication of infections, oral hygiene, and treatment of urinary lesions are carried out. Sympathetic conversations with the patient informing him of the necessity of the procedure as well as of the benefit to be derived engender a cooperative attitude which is often invaluable in trying postoperative situations.

Just prior to operation, even if it is not otherwise indicated, it is often wise to place a gastroduodenal tube in order to aspirate gastric content, particularly if there is to be an upper abdominal procedure. This not only facilitates exposure by virtue of an empty stomach but helps prevent silent aspiration of gastric contents [3] and reduces the period of severe nausea and vomiting postoperatively in patients who have had a general anesthetic irrespective of the operation performed. Endotracheal intubation during the operation is also of value in prevention of pulmonary aspiration as well as in cleaning the tracheobronchial tree and insuring good oxygenation. The possible inflammation and increase in tracheal secretions are far outweighed by these advantages.

Local anesthesia by infiltration, field block, or regional block (including intercostal nerve block) is preferable to general anesthesia if it allows a properly done procedure. If the important parts of the procedure can be done outside of the peritoneal cavity, local anesthesia is useful. If important or prolonged work is necessary within the peritoneal cavity, local anesthesia is likely to be dangerous in that motions and patient discomfort may cause lack of exposure or haste. Most patients will tolerate a properly administered general anesthetic and careful operation better than a poorly done hasty procedure under local anesthesia. Refrigeration anesthesia for amputations is often useful.

Adequate blood replacement during operation is mandatory. In extensive operations sponge weight or other estimation of blood loss is done in order to decrease the large error of guesswork.

The wound should be handled with care. The patient will tolerate a slower gentle operation better than a rapid traumatic one. Small clamps, accurate bites,

---

2. Clark, J. H.; Nelson, W.; Lyons, C.; Mayerson, H. S., and DeCamp, P.: Chronic Shock: The Problem of Reduced Blood Volume in Chronically Ill Patients: Hemoglobin and Red Blood Cell Deficits in Chronic Shock; Quantitative Aspects of Anemia Associated with Malignant Tumors, Ann. Surg. **125**:618 (May) 1947.

3. Culver, G. A.; Makel, H. P., and Beecher, H. K.: Frequency of Aspiration of Gastric Contents by the Lung During Anesthesia and Surgery, Ann. Surg. **133**:289 (March) 1951.

and fine suture material should be used. The closure of the wound is particularly important, for these patients should be ambulatory on the operative day or the next day. Many of them require vigorous endotracheal suction, which results in strain on the wound. Transverse incisions are stronger than longitudinal ones, and experience with them leads to proper exposure for most operations. Steel wire stay sutures need not be used as often in the former as in longitudinal incisions.

A firm, locally tight dressing should be placed in order to splint and support the tissue and to prevent oozing within the wound. Postoperatively, all patients except those with thoracic and toxic thyroid conditions have been kept in the recovery room with special attendants until conscious.

Except in rare cases, patients should become ambulatory on the first postoperative day. This ambulation is active rather than passive. The patient should receive aid in walking short distances several times daily as tolerated. Sitting in a chair for a prolonged period is not satisfactory and may even be more dangerous than bed rest.

Throughout the immediate postoperative period the fluid and electrolyte balance should be maintained by frequent examination of the clinical condition as well as by laboratory tests. Exact recording of the fluid intake and output is essential. Balance is frequently difficult to maintain in the older age group because of complicating disease. In many of these patients, fluid intake must be limited to prevent cardiac decompensation, and it is only by careful observation and delicate maintenance of balance that trouble can be avoided. The urinary output is perhaps the most important single determinant of fluid administration. Blood is administered postoperatively as indicated. Transfusions are not usually necessary immediately if an effort has been made to replace all blood loss in the operating room.

During the postoperative course, most patients should receive supportive vitamin therapy. Antibiotics are not given routinely. However, in many of these elderly patients chronic pulmonary disease is a sufficient indication for the administration of penicillin as a prophylaxis against infection. Micronized penicillin by inhalation should be given to many.[4]

Pulmonary complications are considered to be the most dangerous of any that might occur, and there must be a constant vigil for early detection and treatment. The resident and nursing staffs should be able to use the intratracheal suction tube for excessive secretions and early atelectasis.

As most gastrointestinal patients have an indwelling gastric or intestinal tube, its removal becomes an important problem. All tubes should be removed early. Removal is usually done in the first 48 hours at the onset of peristaltic sounds or passing of flatus. This is also true after gastric surgery with the exception of vagotomy. A tube is disconcerting to a patient and also causes excessive secretions, adding to the difficulty of maintaining a dry tracheobronchial tree. Removal of the tube also facilitates mobilization of the patient.

RESULTS

Analysis of the data obtained by this study of 354 operations in 313 patients over 60 years of age is presented in Table 2. The 32 deaths constitute an over-all

4. Cohen, S. H.; Taplin, G. V., and Mahoney, E. B.: Inhalation of Micropowdered Penicillin and Streptomycin in the Prevention of Postoperative Pulmonary Infections, Surgery **24**:392 (Aug.) 1948.

TABLE 2.—*Statistical Summary of 354 Operations on 313 Patients over 60 Years Old, 1950 to 1951*

Procedure	Cases	Age Distribution							Sex		Status				Mortality			
		60-64	65-69	70-74	75-79	80-84	85-89	90+	M	F	Private	Staff	Emergency	Elective	Elective	Emergency	Total	Total Percentage
Esophagus																		
Resection	2	1	1	0	0	0	0	0	0	2	2	0	0	2	0	0	0	0
Diverticulectomy	2	0	1	0	0	0	1	0	1	1	1	1	0	2	0	0	0	0
Gastroduodenal																		
Suture perforation	7	2	3	1	1	0	0	0	6	1	0	7	7	0	0	1	1	14
Subtotal resection *	27	13	5	6	2	0	0	1	19	8	17	10	5	22	0	1	1	4
Total resection	1	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0
Gastrojejunostomy	7	0	1	5	0	1	0	0	3	4	2	5	0	7	0	0	0	0
Vagotomy, drainage	3	0	2	1	0	0	0	0	3	0	2	1	0	3	0	0	0	0
Gastrotomy	2	1	0	0	1	0	0	0	2	0	0	2	1	1	0	1	1	50
Small Bowel																		
Resection	9	3	3	2	1	0	0	0	6	3	3	6	7	2	0	2	2	22
Jejunostomy	1	0	0	1	0	0	0	0	1	0	0	1	0	1	1	0	1	100
Diverticulectomy	1	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0
Colon																		
Appendectomy	12	5	5	1	0	0	1	0	8	4	5	7	11	1	0	1	1	8
Right colectomy †	7	2	0	2	3	0	0	0	2	5	4	3	1	6	2	1	3	43
Left colectomy	14	3	3	3	3	2	0	0	7	7	12	2	0	14	0	0	0	0
Transverse colectomy	1	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0
Abdominoperineal	6	2	3	0	0	1	0	0	4	2	4	2	0	6	0	0	0	0
Anterior resection	3	0	2	0	0	1	0	0	1	2	0	3	0	3	0	0	0	0
Colostomy	8	0	2	2	2	2	0	0	7	1	4	4	1	7	1	1	2	25
Cecostomy	9	0	3	4	1	1	0	0	6	3	4	5	7	2	0	4	4	44
Close cecostomy	3	0	2	1	0	0	0	0	1	2	3	0	0	3	0	0	0	0
Excision of polyp	1	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0
Biliary																		
Cholecystectomy	38	19	8	5	5	1	0	0	11	27	17	21	12	26	0	0	0	0
Cholecystectomy, exploration of common duct ‡	12	5	3	1	2	0	1	0	5	7	7	5	1	11	1	0	1	8
Cholecystostomy	1	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0
Exploration of common duct	4	0	0	2	2	0	0	0	1	3	2	2	0	4	0	0	0	0
Cholecystogastrostomy	1	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0
Pancreatic-duodenal resection	1	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
Exploratory laparotomy §	24	9	5	7	2	0	1	0	12	12	17	7	6	18	4	1	5	21
Thoracic																		
Pneumonectomy	4	3	1	0	0	0	0	0	4	0	1	3	0	4	0	0	0	0
Lobectomy	1	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0
Exploratory thoracotomy	5	2	2	0	0	0	1	0	4	1	3	2	1	4	0	0	0	0
Thyroidectomy	7	4	1	2	0	0	0	0	1	6	3	4	0	7	0	0	0	0
Breasts																		
Radical mastectomy	10	4	5	0	1	0	0	0	1	9	8	2	0	10	0	0	0	0
Simple mastectomy	6	0	2	1	2	0	1	0	1	5	2	4	0	6	0	0	0	0
Hernia																		
Inguinal, femoral	44	11	17	6	5	4	1	0	40	4	18	26	5	39	0	1	1	2
Ventral	11	7	3	1	0	0	0	0	3	8	8	3	2	9	1	1	2	18
Hiatus (transthoracic)	2	1	0	1	0	0	0	0	2	0	0	2	0	2	0	0	0	0
Lumbar sympathectomy	17	6	2	5	3	1	0	0	14	3	5	12	0	17	0	0	0	0
Amputations																		
Supracondylar thigh	28	5	7	9	2	4	0	1	13	15	6	22	2	26	6	1	7	25
Midcalf	5	3	2	0	0	0	0	0	5	0	3	2	1	4	0	0	0	0
Embolectomy, femoral	2	1	1	0	0	0	0	0	1	1	1	1	2	0	0	0	0	0
Neck dissection	4	1	2	1	0	0	0	0	3	1	1	3	0	4	0	0	0	0
Thyroglossal cyst	1	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0
Total	354	119	99	71	38	18	7	2	204	150	169	185	73	281	16	16	32	9.0

* Included one simultaneous cholecystectomy.
† Included one simultaneous cholecystogastrostomy.
‡ Included one simultaneous right colectomy.
§ Included exploration with biopsy, lysis of adhesions, drainage of abscess, and excision of retroperitoneal tumor.

operative mortality of 9.0% and an over-all patient mortality rate of 10.2%. Since each individual operation exposes the patient to risk, we have considered the operative mortality rate in later sections rather than the patient mortality. Any patient who did not leave the hospital alive was included in the operative mortality. In several instances this probably unjustifiably increased the mortality rate.

The mortality rate of 8.8% in male and 9.3% in female patients as noted in Table 3 indicated no statistical difference between men and women. The data in Table 4 indicated a greater mortality rate in ward patients than in private patients, in both elective and emergency operations. There are two probable explanations for this, namely, the much poorer general physical condition of ward patients and less experienced operators.

Figure 1 indicates the incidence of operations and operative mortality by age. Because of diversified factors, such as unequal distribution of emergency-type procedures and types of operations peculiar to different age groups, it is felt that these mortality rates are statistically unreliable.

TABLE 3.—*Sex Incidence and Mortality in 354 Operations*

Sex	Cases	Deaths	Mortality, %
Male	205	18	8.8
Female	149	14	9.3
Total	354	32	9.0

TABLE 4.—*Analysis of Mortality by Status and Nature of Operation*

	Operations	Deaths	Mortality, %
Emergency			
Private	18	1	5.6
Ward	55	15	27.3
Elective			
Private	151	6	3.9
Ward	130	10	7.7
Total	354	32	9.0

Figure 2 shows the greater mortality rate of emergency operations (21.9%) than of elective operations (5.7%). These figures are comparable to those published by other authors.

In Table 5 are listed the 32 deaths which occurred in this series postoperatively. Patients who died of intercurrent disease or of continuation of the current lesion after discharge from the hospital were not included in the postoperative deaths, since discharge from the hospital indicated recovery from the immediate effects of the operation. Cardiovascular disease, including cerebral vascular accidents, myocardial infarction, and cardiac failure accounted for the greatest number of deaths. Fatal pulmonary embolism occurred in five cases. In one of these the condition was diagnosed clinically and treated conservatively. The patient, the only one to die from appendectomy, had a massive pulmonary embolus as she was leaving the hospital on the 36th postoperative day. In the other four cases the condition occurred insidiously in patients with other complicating disease. Hepatic failure occurred in two patients with advanced cirrhosis, both of whom had been operated on for massive gastrointestinal hemorrhage, in one from a peptic ulcer and in the other from varices. Bronchopneumonia accounted for two deaths. It should be pointed out

that these are the principal causes of death and that several patients who exhibited bronchopneumonia at necropsy had more important factors contributing to their deaths. Other causes of death included gastrointestinal hemorrhage, peritonitis from leaking anastomosis, renal failure, generalized carcinomatosis, intestinal

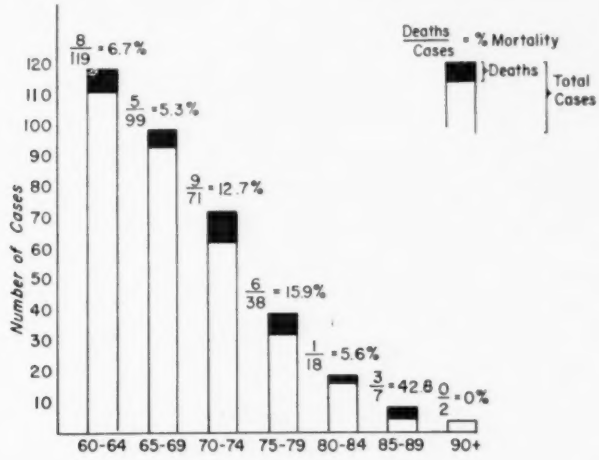


Fig. 1.—Age incidence and mortality rates.

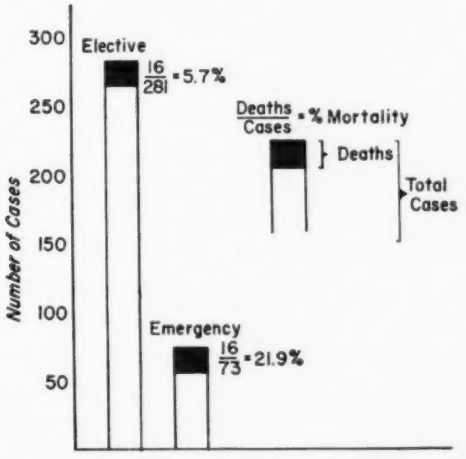


Fig. 2.—Incidence and mortality rates of elective and emergency operations.

obstruction, and overwhelming gas bacillus infection with toxemia. Both cases of intestinal obstruction involved patients with advanced carcinoma.

Further analysis of the postoperative deaths indicates that 7 of the 32 patients who died had advanced inoperable carcinomatosis. Operation undoubtedly hastened death in some of these. But consideration of these as well as of the single case of

massive small-bowel resection for superior mesenteric thrombosis shows the reported mortality rates to be maximal. Adjustment would in any case tend to decrease the figures.

TABLE 5.—*Summary of Thirty-Two Deaths*

Patient	Sex	Age	Procedure	Postoperative Day of Death	Chief Cause of Death
			Elective		
A. B.	M	60	Laparotomy and drainage of abscess	3d	Pulmonary embolism
A. D.	F	88	Cholecystectomy and exploration of common duct	13th	Cardiac failure
L. S.	F	74	Thigh amputation	15th	Myocardial infarct
A. P.	M	80	Thigh amputation	20th	Myocardial infarct
A. D.	F	69	Thigh amputation	58th	Myocardial infarct
C. S.	M	61	Thigh amputation	21st	Gas infection, shock
H. F.	M	72	Jejunostomy (pyloric obstruction)	6th	Bronchopneumonia, cardiac failure
F. K.	M	77	Laparotomy (carcinomatosis from sigmoid)	6th	Pulmonary embolism
A. G.	M	76	Colostomy (inoperable carcinoma, sigmoid)	9th	Atelectasis, pneumonia
J. R.	F	61	Ventral herniorrhaphy	2d	Transfusion reaction
F. T.	F	72	Laparotomy and drainage of pelvic abscess	13th	Gastrointestinal hemorrhage
N. J.	F	79	Colectomy, right	8th	Peripheral vascular collapse
W. H.	M	73	Laparotomy and biopsy (carcinoma, sigmoid)	15th	Bowel obstruction, pneumonia
G. D.	M	60	Colectomy, right (recurrent carcinoma)	7th	Peritonitis from anastomotic leak
L. B.	F	75	Thigh amputation	1st	Myocardial infarct
F. S.	F	60	Thigh amputation	14th	Pulmonary embolism
			Emergency		
F. H.	M	77	Colectomy, right (carcinoma)	35th	Volvulus, small bowel
F. M.	M	64	Thigh amputation	1st	Myocardial infarct
M. O.	F	66	Ventral herniorrhaphy	2d	Myocardial infarct
L. W.	F	70	Subtotal gastrectomy (bleeding ulcer)	4th	Cerebral accident, pneumonia
C. S.	M	82	Colostomy (inoperable carcinoma, rectum)	6th	Pulmonary embolism
M. W.	F	67	Cecostomy (diverticulitis with obstruction)	11th	Cardiac failure
B. N.	M	65	Resection of small bowel (volvulus, carcinomatosis)	On table	Question of cardiac arrest
J. O.	M	76	Resection of small bowel (superior mesenteric thrombosis)	1st	Shock, pulmonary aspiration
I. K.	F	86	Inguinal herniorrhaphy (incarcerated)	1st	Recurrent cerebral accident
C. B.	F	64	Appendectomy	36th	Pulmonary embolism
M. B.	F	71	Cecostomy (carcinomatosis from sigmoid)	14th	Carcinomatosis
I. E.	M	86	Cecostomy (carcinoma, splenic flexure)	5th	Atelectasis, pneumonia, cardiac failure
A. D.	M	72	Laparotomy and packing of liver (bleeding hepatoma)	10th	Renal failure, shock
C. R.	M	65	Suture of perforated ulcer (advanced cirrhosis)	3d	Hepatic failure, bleeding ulcer
R. T.	M	70	Cecostomy (carcinoma sigmoid)	6th	Cardiac failure, atelectasis
J. C.	M	76	Gastrotomy, ligation of varices	4th	Cirrhosis, hepatic failure

COMPLICATIONS

Two hundred three complications occurred in this series. Since there was the possibility of multiple complications in each patient, this figure cannot be expressed as a percentage complication rate. Table 6 lists the analysis of these data in relation to the surgery performed. Fifty of the complications followed emergency and 153

followed elective surgical procedures. Pulmonary complications were by far the most numerous, bearing out general clinical observations in this age group particularly. Part of the high incidence of these complications is due to the continuous search for lung complications in every patient in the postoperative period. We feel that the pulmonary system is the greatest potential source of morbidity to the old patient and that any lesion contributes toward mortality.

The management of established complications should consist of early and vigorous measures. Principles of management of some of the more important complications are outlined below.

TABLE 6.—*Postoperative Complications in 354 Operations**

		Complications																		
		Chest			Cardiac			Wound				Phlebitis		Cerebral		Bowel				
Procedure	No. of Cases	Atelectasis, Pneumonia	Fluid	Pneumothorax	Infarction	Failure	Arrhythmia	Fluid	Infection	Dehiscence	Urinary	Without Embolism	With Embolism	Psychosis	Other (Cerebrovascular Accidents)	Obstruction	Bleeding	Fistula	Peritonitis	Other	Total
Esophageal	4	2	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	....	4
Gastroduodenal	47	15	..	..	1	1	2	..	1	2	8	1	1	1	2	3	5	1	..	Subphrenic, 1; hepatic failure, 1	46
Small bowel	11	4	..	..	..	1	..	..	..	..	..	1	..	..	..	1	1	..	..	....	8
Colon	64	11	1	..	..	3	2	1	3	4	8	1	3	1	..	5	..	2	1	Shock, 1	47
Biliary	57	7	..	..	..	1	2	..	2	1	2	..	1	..	..	..	..	..	..	....	16
Exploratory laparotomy	24	2	1	..	..	..	1	..	..	2	..	..	3	..	1	3	..	1	..	Renal failure, 1; liver failure, 1	16
Thoracic	10	3	3	1	..	1	2	1	..	..	..	..	..	..	..	..	..	..	..	....	11
Thyroid	7	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	Tracheotomy, 1	3
Breast	16	0	..	..	..	..	..	6	..	..	..	..	..	..	..	..	..	..	..	Flap necrosis, 3; neurologic, 1	10
Hernia	57	1	..	..	1	..	..	2	1	..	6	..	1	1	1	..	..	..	..	Transfusion reaction, 1	15
Lumbar sympathectomy	17	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	....	1
Amputations	33	3	..	..	5	1	..	..	6†	1	4	..	1	..	..	..	..	..	..	Shock, 1; superior mesenteric thrombosis, 1	23
Other	7	1	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	....	3
Totals	354	50	5	1	7	9	11	12	14	10	28	3	10	3	4	12	6	4	1	13	268

* Multiple complications in any individual case were tabulated separately.
† Includes one case of gas infection.

Pulmonary Complications.—In the early postoperative period pulmonary complications are largely due to bronchial or bronchiolar obstruction, with resulting atelectasis of the blocked off pulmonary tissue due to blood absorption of the trapped gas. Primary bacterial pneumonia is rare postoperatively, but pneumonitis secondary to multiple small atelectases is common. Since bronchial obstruction, atelectasis, and bronchopneumonia are closely associated processes, we have considered this type of complication as a unit in analysis of the data, finding it to be the most frequent single complication (50 instances). The diagnostic incidence has been largely due to awareness and to an active search for it in order to reaerate the pulmonary tissue at the earliest possible time. This prevents further development of pneumonitis and decrease in pulmonary function, especially important in the elderly patient.

Prophylaxis of lung complications was started early in the postoperative period, consisting in encouragement in coughing (supporting the wound where pain inhibited the ability to cough), rebreathing a 10% carbon dioxide and 90% oxygen mixture by mask until hyperpnea resulted three times daily, and early ambulation. Endotracheal suction was carried out in many patients, at times as often as every hour. It was apparent that time spent in the first 48 postoperative hours in preventing pulmonary complications was repaid later in terms of good convalescence and decrease in needed care.

The first evidence of small areas of atelectasis was usually a low fever, with or without tachycardia and dyspnea. Physical signs were often limited to sticky basal rales, with some depression of sounds. This syndrome usually responded to treatment (directed at reaeration of the pulmonary tissue) by decrease in fever and clearing of signs. If it continued despite coughing, endotracheal suction, and ambulation, bronchoscopy was done, although most patients were handled without the necessity for this. If necessary, bronchoscopy was done easily in bed, oxygen being supplied by a side-arm vent to a few hypoxic patients. Occasionally a tracheotomy was necessary to control secretions.

The more easily recognized massive type of atelectasis, in which an entire lobe or lung was blocked off, occurred less frequently. Bronchoscopy was immediately done to open these large areas of pulmonary tissue. Administration of antibiotic therapy, in the form ordinarily of penicillin, was started once a pulmonary complication became evident, if it was not previously under way.

We wish to reiterate the importance of postoperative pulmonary complications caused by obstruction of a part of the tracheobronchial tree. Its frequency merits much attention to prophylaxis as well as to treatment. Early postoperative fever should be regarded as pulmonary in origin until proved otherwise.

Intrapleural complications include the presence of fluid (five cases), pneumothorax (one case) and infection (no instances in this series). In the majority of thoracic cases pleural drainage by indwelling catheter attached to suction was carried out, so that thoracentesis was not often necessary. Obliteration of the pleural space by rapid expansion of the lung (or remaining portion if resected) prevents further accumulation of fluid which may become infected. After pneumonectomy this, of course, was not done. Empyema did not occur in the small series at hand. The single case of pneumothorax did not necessitate more than needle aspiration via the anterior second interspace. In other cases, not included in this series, this complication has recurred, however, necessitating suction or water-seal drainage.

Cardiac Complications.—Cardiac complications in the form of myocardial infarction, arrhythmias, and decompensation occurred not infrequently. Routine preoperative cardiac consultation and electrocardiograms led to awareness of the functional status and gave a baseline to compare with later changes. Preoperative administration of digitalis and quinidine was used when indicated. Digitalization was carried out if there was any positive evidence of cardiac decompensation such as dependent edema, dyspnea, orthopnea, or pulmonary congestion or a definite history of cardiac decompensation in the past.

Postoperatively, myocardial infarction was an indication for strict bed rest. At times decompensation in this period necessitated digitalization. Since some patients showed questionable decompensation in the form of tachycardia and responded

excellently to digitalization, we have at times used this measure earlier than might be considered usual. In this series cardiac complications occurred 27 times. There were five deaths directly attributed to myocardial infarction, and two followed decompensation from another cause.

Urinary Complications.—Urinary complications are of two types, namely, obstruction with retention and infection. In this series these have been grouped together since they are usually associated. Urinary complications occurred in 28 instances, illustrating that they are common. Many old persons have difficulty voiding after operation. This difficulty was combated initially by allowing the patient to stand while attempting to urinate. Small enemas and injections of neostigmine (prostigmin®) or bethanechol (urecholine®) chloride were also used. Catheterization was done if for any reason the patient was unable to void after 8 to 12 hours during which time the above measures were tried. If repeated catheterization became necessary, an indwelling tube was placed and allowed to remain for a few days until convalescence progressed to a point at which spontaneous urination seemed likely. Indwelling catheterization has the advantage of preventing bladder overdistention and retention of urine with supervening infection. It also allowed measurement of output. At times it was done for the latter purpose alone, especially in persons with major fluid or electrolyte imbalances. Prophylaxis against infection during the period of catheterization consisted of administration of gantrisin® (a sulfonamide compound) in doses of 0.5 gm. four times daily. If culture showed persistent infection, other drugs were used as indicated by the cultured organism and its sensitivity. Some men with previous benign prostatic hypertrophy are never able postoperatively to regain their former ability to void, and prostatic resection, usually by the transurethral route, may be necessary within a few weeks.

Gastrointestinal Complications.—These usually centered about ileus, either dynamic or paralytic, with resultant fluid and electrolyte imbalance. While fluid and electrolyte replacement were done, the gastrointestinal tract was decompressed by intubation with the expectation that relief of distention of the bowel wall would be followed by diminution of the inflammatory process or by spontaneous return of peristaltic motion after adynamic ileus. Levin tubes were used for gastroduodenal decompression, and a long, single-lumen tube with a mercury-filled latex bag attached to its end (Harris tube)[5] was passed for small-bowel decompression. The latter was usually passed spontaneously through the pyloris after a few hours during which the patient lay on his right side. After an x-ray study or fluoroscopy verified passage into the duodenum, the tube was allowed to pass by feeding its length into the nasopharynx at the rate of 2 in. (5 cm.) per hour. Further x-ray studies followed its progression. Fluids were limited to cracked ice in small quantities while the tube lay in the stomach or duodenum in order to prevent depletion of chlorides, but after the tube passed well into the small bowel the portion of tract above its tip could be utilized to absorb limited quantities of fluid, salts, and even thin food materials. Once the Harris tube was in its desired position it was not removed until, after occlusion for 24 hours, the patient demonstrated ability to handle a full fluid diet without recurrent ileus.

5. Harris, F. I.: Intestinal Intubation in Bowel Obstruction: Technique with New Single Lumen Mercury Weighted Tube, Surg., Gynec. & Obst. **81**:671 (Dec.) 1945.

Mechanical obstruction due to edema and inflammation, especially that about the anastomosis in the bowel, will ordinarily subside rapidly. If subsidence did not occur, it was necessary to do a secondary procedure to insure an alimentary passage. Fibrinous adhesions kinking the bowel or anastomosis necessitated lysis, and rarely a secondary resection and anastomosis or enteroenterostomy was necessary. Intubation does not decompress the colon whose ileocecal valve is competent, and obstruction at an anastomotic site may necessitate cecostomy or colostomy if such was not done as a complemental procedure at the original operation. In this series postoperative obstruction occurred 12 times. In two patients whose condition was terminal because of carcinoma the cause of death was small-bowel obstruction.

Postoperative bleeding occurred six times in this series. One patient with advanced cirrhosis died from hemorrhage from a peptic ulcer which had been plicated. Bleeding from anastomotic lines was treated with transfusions as indicated, because in most of the cases the bleeding ceases. Occasional patients continued to bleed, and it became necessary to reexplore the site for control of hemorrhage, a procedure fraught with even greater dangers than the primary operation. This procedure was necessary only once in this series. If the site of hemorrhage is within the stomach or duodenum, it is worth while to attempt to control it by the use of buffered thrombin solution placed through an indwelling gastroduodenal tube.[6] The use of this was at least coincidental with cessation of bleeding in a few patients here. Bleeding from esophageal varices has been well controlled by the use of the Sengstaken tube,[7] which compresses the varices. Extreme sedation is necessary during the use of this tube to insure proper position.

Because it is felt that there is no completely reliable clinical test for the development of venous thrombosis, there is no established routine for the prophylaxis of thrombophlebitis or phlebothrombosis in this hospital. The policy that has been followed is one of close observation for the early signs of venous disease. If the diagnosis of venous thrombosis was made, we used a course of anticoagulant therapy, usually heparin and bishydroxycoumarin (dicumarol®), plus bed rest. After five to seven days of complete bed rest, there was a period of five to seven days of gradual mobilization. Venous ligations have not been used except for frank pulmonary embolization. Even a single embolus might not denote immediate ligation. If a second embolus occurred during anticoagulant therapy, bilateral superficial femoral ligation was done. In this series venous thrombosis, as diagnosed by clinical signs, occurred 13 times. There were five fatal pulmonary emboli, only one of which was diagnosed clinically. This one was treated conservatively. The diagnosis in the other four was made by postmortem examination.

Fluid and Electrolyte Imbalance.—Fluid and electrolyte imbalance was carefully followed by chemical tests as well as by clinical appearance and measurement of intake and output. Insensible loss, which in hot weather or in the presence of fever may amount to 1,500 cc. daily, should be considered along with losses through diarrhea, fistulae, indwelling gastrointestinal tubes, and emesis. It is, however,

6. Daly, B. N.; Johnson, C. G., and Penberthy, G. C.: The Management of Patients with Bleeding from the Upper Gastro-Intestinal Tract with Buffer and Thrombin Solution, Ann. Surg. **129**:832 (June) 1949.

7. Sengstaken, R. W., and Blakemore, A.: Balloon Tamponage for the Control of Hemorrhage from Esophageal Varices, Ann. Surg. **131**:781 (May) 1950.

important not to overload the circulatory system with fluids, and it is better to keep old patients on the "dry side." An average of 2,000 to 2,500 cc. of fluid (5% dextrose in water and saline when indicated) is usually sufficient to maintain hydration and an adequate urinary output if the loss through the above-mentioned diarrhea, fistulae, and intestinal tubes is not excessive. Five per cent dextrose in water was preferred to saline or Ringer's solution in the first 24 to 48 hours after operation since retention of sodium and water is likely to occur.[8] Potassium losses continue while the kidneys function, and if there is no potassium intake a deficiency will occur.[9] When this was considered likely, prophylactic doses of 30 mEq. of potassium per day were given intravenously in 5% dextrose. If hypopotassemia had already occurred, as denoted by the clinical course, electrocardiogram, or chemical test, therapeutic doses of 60 to 120 mEq. of potassium in 5% dextrose were given until the deficiency was replaced.

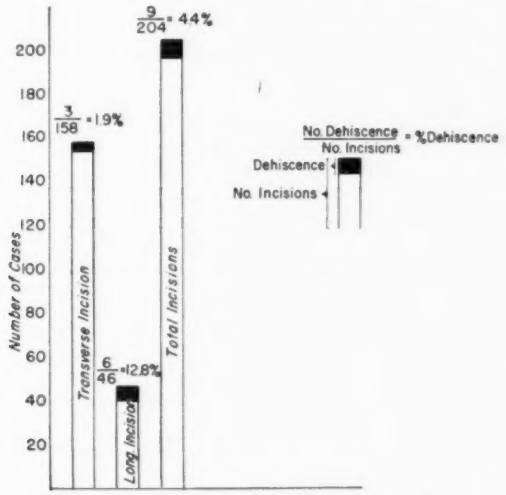


Fig. 3.—Incidence of wound dehiscence in 204 laparotomies.

Wound Complications.—These include fluid accumulation, infection, and dehiscence. The 14 instances of infection were treated by opening the wound to drain pus and the use of rest, compresses, and antibiotics according to the organism involved. Fluid accumulation occurred in 12 instances without infection. Aspiration of this fluid was done through the skin apart from the incision. This complication was prominent in six of the radical mastectomies in which multiple aspirations were necessary.

Wound dehiscence constitutes a severe complication for any patient, but especially an old one. Attempts to prevent this preoperatively by correction of malnutri-

8. Moyer, C. A.: Acute Temporary Changes in Renal Function Associated with Major Surgical Procedures, Surgery **27**:198 (Feb.) 1950.

9. Evans, E. I.: Potassium Deficiency in Surgical Patients: Its Recognition and Management, Ann. Surg. **131**:945 (June) 1950. Marks, L. J.: Potassium Deficiency in Surgical Patients, ibid. **132**:20 (July) 1950.

tion and of depleted blood volume followed by careful wound management did not eliminate it. Interrupted silk (000 and 0000) sutures were used for closure of the great majority of the wounds. Through-and-through retention sutures of steel wire were placed in some of the wounds, chiefly the longitudinal ones. No buried steel wire sutures were used in this series.

In Figure 3 are found the data derived from 204 abdominal wounds occurring in this series. Although the transverse incision was used about three times more than the longitudinal ones, its rate of dehiscence was about one-seventh as great. Since it was possible that the longitudinal incision was being used when the risk of dehiscence was greater, analysis of incisions used in emergency operations was made, which showed that of the 58 emergency laparotomies, 42 were done through transverse incisions, an incidence of 72% transverse incisions in emergency laparotomy. This seems to confirm published statements [10] that transverse abdominal incisions give stronger wounds as well as our staff's preference for them.

If dehiscence occurred, the wound was at once resutured in the operating room, through-and-through steel wires plus interrupted silk in the skin being used. The

TABLE 7.—*Average Life Expectancy Based on 1940 United States Census Figures*

Attained Age, Yr.	Life Expectancy, Yr.
60	15.9
65	12.8
70	10
75	7.6
80	5.7
85	4.3
90	3.3
95	2.6
100	2.1

skin sutures were removed after about seven days, while the steel stay sutures were left in place for 10 to 16 days. At times recurrent dehiscence may necessitate a second resuture. The single instance of this occurring in this series was allowed to granulate beneath compresses since it was small, the bowel was fixed firmly to the peritoneal edges, and the abdominal wall had multiple infected sinuses at the site of the previously placed stay sutures.

COMMENT

The principles of management of elderly patients do not differ essentially from those used in younger persons. However, because of decreased functional reserve, it is particularly important to prevent further loss of this reserve by continued attention to the host of details which bolster the individual systems as well as the patient as a whole. The physiologic mechanisms are more easily deranged in old persons, and a vicious cycle of complications leading to ultimate death is common.

Life expectancy at an attained age is greater than that expected at any earlier age. Table 7 indicates this. Even though the expectancy be low, the individual is entitled to whatever aid can be provided toward health and comfort.

10. Gurd, F. B.: Anatomical Principles Involved in Abdominal Incisions, S. Clin. North America **25**:271 (April) 1945. Singleton, A. O.: Surgical Wounds of the Abdominal Wall with Their Favorable and Unfavorable Results, Am. J. Surg. **73**:233 (Feb.) 1947.

The physiologic age does not necessarily parallel the chronologic age. Many patients old in years have systems which are nevertheless in much better functional condition than the average at the same chronologic age. The opposite is also true. These patients should therefore be evaluated on an individual basis of physiologic function, not particularly related to years of life attained. We have felt that in many instances the mere fact of chronologic age attainment indicated stamina and ability to cope with the stresses which have almost necessarily previously occurred. In advanced age the individual has of necessity proved himself to have possessed superior physical functions. Old persons are proved performers while younger ones have not gone far enough along to be proved.

Our experience parallels that of others in that emergency procedures are associated with higher mortality rates than are elective procedures. This points to the necessity for decreasing the number of emergency operations by doing elective ones before urgent intervention becomes necessary. Operations for hernia are the outstanding example, and that for cholelithiasis is another. Most patients who are regularly up and about and who have symptomatic hernias will tolerate elective repair, especially if local anesthesia is used. The same applies in lesser degree to gall bladder surgery, although the mortality ratio may be less.

The diversity of operative procedures in this series makes it impossible to discuss indications and methods individually. Some general statements may be made, however, to indicate our general approach to surgical problems in this age group. Patients have been advised regarding operation on an individual basis. Probable gain in terms of life and function have been weighed against the probable risk of operation for the particular person. When death appeared certain at once without operation, the latter has not been refused in order to prevent possible operative mortality. Certain palliative procedures have been done for grave-risk patients whose present suffering was, or future suffering would be, great. When a choice of procedure was possible, the risks of the two were compared to the probable advantages of each. These decisions have been made after discussions with patient and family and in consultation not only between surgeons but also with internists, cardiologists, and representatives of other services as indicated. A maximum effort by the consultant group is often necessary to attend to the multitude of details of care which aid the patient to recover. Without easy availability of expert opinion and technic along specialized lines, many methods of care would not have been possible.

Operative Procedures.—Perforated ulcers have been operated on by simple suture as soon as the patient's general condition would permit. Omentum has at times been used to reinforce the suture line. Primary gastric resection in the face of perforation has not been done. Subtotal gastrectomy has been generally preferred to vagotomy as surgical treatment of peptic ulcer in this age group. Gastroenterostomy has been done in some poor-risk patients with pyloric obstruction. Upper gastrointestinal bleeding has been managed without operation so far as possible. When, after stabilization has been obtained, massive hemorrhage recurred so that more than about 1,000 cc. of blood per day was required to replace lost blood, subtotal gastrectomy has been done. Five of the 27 gastrectomies were done on this basis.

Early operation has largely replaced intubation management of mechanical bowel obstruction. Intubation has been used during the preoperative preparation of the patient. Colonic obstruction has been treated by cecostomy or colostomy prior to definitive procedures for carcinoma or diverticulitis. When resection was necessary, continuity has been established by primary anastomosis rather than by staged exteriorization procedures. If adequate bowel preparation has been possible, open anastomoses have been generally preferred to the closed type. This is true in even greater degree in the small bowel and the stomach.

Appendicitis has been treated by appendectomy rather than by drainage procedures when the appendix could be found and removed without difficulty. Drainage has been reserved for instances in which pus collection or much necrotic tissue was present. Otherwise the abdomen has been closed tightly without drainage, antibiotic bolstering of the peritoneal defenses being depended on to control peritonitis. If wound infection occurred, the wound itself was reopened later.

We believe that the treatment of choice for acute cholecystitis is cholecystectomy after proper preparation of the patient. Accordingly, operation has generally been deferred only for 8 to 24 hours. Cholecystectomy has been done rather than cholecystostomy if technically feasible and if the general condition of the patient permitted. General anesthesia enabling proper exposure is imperative for safe cholecystectomy. If this appears too risky for the patient, cholecystostomy can be done safely under local anesthesia. Exploration of the common duct was done when indicated. Thirteen of the 50 cholecystectomies (with and without common-duct exploration) were emergency procedures, whereas only one cholecystostomy was done. The results of this series (no mortality) indicate a satisfactory policy in this group.

Herniorrhaphy was not refused on the basis of chronologic age. If there appeared to be a reasonable chance of future ambulatory life and if the hernia was symptomatic, its repair was advised. If incarcerated hernia could not be reduced within a few hours, operation was urged.

A series of lumbar sympathectomies was done in an attempt to learn the value of this procedure in peripheral arterial insufficiency in the older age group. Insufficient time has elapsed for proper evaluation of the results. The operation itself could be done with low mortality and morbidity and was offered in a number of instances for final decision by the patient. Since the advent of antibiotics, the danger of infection in peripheral vascular disease has decreased, obviating necessity for many emergency amputations. It is extremely important for these persons to be able to get about, and amputation has been deferred in favor of local excisions in an attempt to salvage some weight-bearing part of the extremity wherever possible. If necessary, supracondylar closed amputation has been the procedure of choice. All these procedures have been classed as elective unless the indications permitted only such delay as would enable the general condition of the patient to be improved. Refrigeration anesthesia is useful in this regard.

SUMMARY

Analysis of a consecutive series of 354 major operations in 313 patients beyond the age of 60 in the one-year period between July 1, 1950, and July 1, 1951, has indicated an over-all operative mortality rate of 9.0% (patient mortality rate of 10.2%).

Emergency operations are more dangerous to old patients, as evidenced by a mortality rate of 21.9% for emergency operations as compared with a mortality rate of 5.7% for elective operations.

Further analysis of the deaths shows that if patients already doomed by the disease process involved are excluded the adjusted death rate would be considerably lower, indicating how well operations are tolerated by patients in this age group.

Study of the complications which occurred indicates the importance of the prevention of pulmonary lesions, which were most frequent in this series.

The clinical management of patients in the older age group is discussed. General principles of management of the common complications, particularly those occurring in this series, are outlined.

Department of Surgery, The Medical College of Alabama, The University of Alabama, Birmingham, Ala. (Dr. Dale).

PILONIDAL SINUS

An Evaluation of Plastic Closure Using Flaps of Gluteal Muscle

RICHARD W. DWIGHT, M.D.
FRAMINGHAM, MASS.

IN A TWO-YEAR period, 245 patients with pilonidal sinus, representing 11% of the admissions to the General Surgical Section, were treated at this hospital. Because many of the patients lived at distances that precluded treating them as outpatients, a method of management was sought that would not require the long period of hospitalization necessitated by the slow healing of open pilonidal wounds.

The technique of Shute, Smith, Levine, and Burch [1] of using flaps of gluteal muscle to close the dead space left by removal of the sinus was selected for trial. One hundred thirty-five patients were treated by this method, 27 of the operations being performed by me and the rest by the resident staff under my supervision.

The patient received a nonresidue diet and cleansing enema the day before operation. Penicillin, either 25,000 units intramuscularly every three hours or a single daily dose of 300,000 units of one of the long-acting preparations, was given 24 hours before operation and continued until the fifth postoperative day. After preliminary shaving, the skin of the area was prepared with phisoderm,® alcohol, ether and benzalkonium chloride (tincture zephiran chloride®), with the patient lying prone, his hips slightly flexed and his buttocks pulled laterally by adhesive tape. A single-dose spinal anesthesia was used in all cases.

An elliptical incision, pointed at the upper end and rounded at the lower, was made to include all sinus openings, with a margin of 1 cm. above the highest and below the lowest. It was at least 4 cm. wide to provide the exposure necessary to develop the gluteal flaps. The incision was carried vertically down to the gluteal fascia and presacral fascia. The skin, fat, and cyst were removed in one piece, care being taken not to cut into the cyst or the gluteal fascia. The specimen was examined, and if it was found that the lesion had been cut across (this usually happens at the lower end) the remaining portion was excised. The gluteal fascia and underlying muscle were then incised approximately parallel to the skin incisions. These incisions were made sufficiently far apart so that the flaps thus created were wide enough to fold to the midline and meet without tension. The depth of the incisions into the muscle had to be sufficient to allow free mobilization of the flaps; usually it was about 2 cm. (Fig. 1). This part of the operation was

Assistant Chief, Surgical Service.
From the Surgical Service, Cushing Veterans Administration Hospital.

Reviewed in the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the author are the result of his own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

1. Shute, F. C., Jr.; Smith, T. E.; Levine, M., and Burch, J. C.: Pilonidal Cysts and Sinuses, Ann. Surg. **118**:706-716 (Oct.) 1943.

usually attended by considerable bleeding. Hemostasis for the entire operation was accomplished by electrocoagulation. The musculofascial flaps were united with interrupted sutures of 000 silk. The adhesive strapping of the buttocks was then cut, and the edges of the fascia lateral to the flaps were brought together with No. 1 silk, as there was always some tension (Fig. 2). It was found to be important to

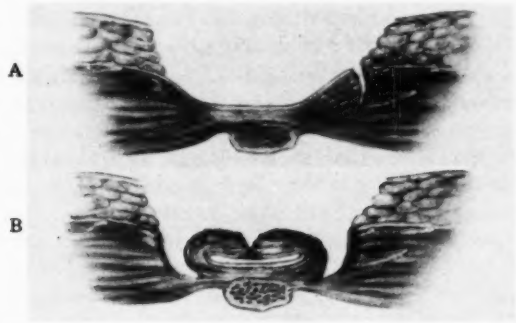


Fig. 1.—*A*, development of muscle flap after excision of cyst; *B*, suture of muscle flaps.

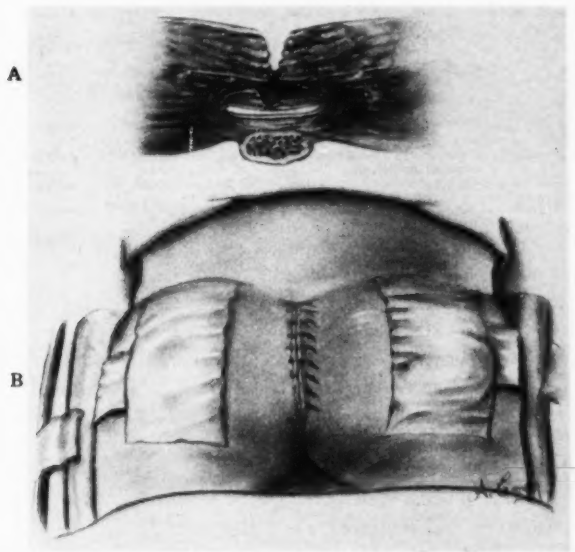


Fig. 2.—*A*, closure of fascia above muscle flaps; *B*, completed operation. Adhesive straps, used for retracting the buttocks, have been cut.

mobilize the skin below the lower end of the incision in the midline before this layer of sutures was placed. There is a raphe in the midline running from the coccyx to the anus and extending out to the skin, which fixes the skin in the midline, causing the crease between the buttocks. This crease is eliminated in the area operated on. Unless it was undercut for a distance of 3 cm. below the end of the incision,

the skin was pulled in at this point and formed a dimple. After the fascial stitches were tied, the skin edges came together without tension and were united by vertical mattress sutures.

In the last 20 cases stainless steel wire sutures were used throughout, with no apparent difference in the operative results.

Postoperatively the patients remained in bed until the seventh day and received 10 minims (0.60 cc.) of deodorized tincture of opium three times a day and a low residue diet until the fifth day. Stitches were removed on the seventh day.

The operation was used at first in nearly all cases of pilonidal sinus except for those with acute abscesses, which were drained and then operated on for definitive treatment, four to six weeks later. After three consecutive failures in patients who had scarring from previous excision, recurrent cases were excluded. Single lateral tracts extending beyond the limits of the usual ellipse could be handled by an additional incision extending outwards and closed in linear fashion. If there were multiple lateral tracts, or sinuses within 2 cm. of the anus, closure was not attempted.

Operative Results

	No. of Cases	Percentage	Patients Reoperated On	Healed Without Reoperation	Average Healing Time	
					With Reoperation	Without Reoperation
Major sepsis	13	10 *	8 †	3	21 wk.‡	14 wk.
Minor sepsis	8	6 *	0	8	.....	6 wk.
"Recurrence" (see text)	16	13 §	13	3	13 wk.‡	22 wk.
Minor defects in scar corrected in outpatient department	11	9 §	0	11	.....	.....
No complications	81	63 §	..	..	.....	.....

* Percentage of 135 operations.
† Untraced—two patients in whom the operation failed because of major sepsis and six patients who left the hospital healed after the original operation.
‡ This does not include the time between discharge after the first operation and readmission for the second.
§ Percentage of 127 patients followed for one year or longer.

It was also found difficult to develop a muscle flap high up on a broad sacrum, and closure was not attempted when this situation existed.

The 110 patients for whom this operation was considered unsuitable for the above reasons will be reported separately.

There were no complications other than those connected with the wound itself. One patient had hemorrhage two hours after operation. His wound was reopened and the bleeding controlled, and he made an uneventful convalescence.

In 13 (10%) of the original 135 cases there was major wound infection requiring reopening of the wound on the 4th to the 11th day (Table). Two of these cases were among the untraced ones. The two patients were being treated as outpatients, and their wounds were still unhealed when last seen 12 and 18 weeks after the operations. Three of the infected wounds healed without reoperation and had remained healed one year later. The remaining eight patients required reoperation. Six of the wounds had healed with packing within 7 to 12 weeks after the original operation and had then broken down, requiring reoperation, with a resultant excessive total loss of time, demonstrating that in the event of sepsis, the safest course was to reopen the incision completely and remove all suture material.

Sixteen other patients left the hospital healed and returned with open wounds or new sinuses. In two of these the cause was apparently traumatic, being a simple

splitting of the scar in one very obese patient and recurrent drainage following a fall on the end of the spine in another. Four patients returned with drainage within two weeks of leaving the hospital, suggesting hidden imperfection in healing at the time they left. Three of these did not require reoperation.

In 10 cases there seemed to be a true recurrence, with one or more sinus openings and a nest of hair. Nine of these recurrences originated at the lower end of the scar, and in seven of them the mechanism was obvious—depression at the junction of the lower end of the scar and the normal skin in the midline below it. This was noted at the time of discharge in four of them; in three it was apparent at the first follow-up visit six weeks later. Loose hairs collected in these depressions, or the hair growing on the skin in that region had a tendency to point inward and upward. In one case the hair growing from the skin was actually extending inward through the sinus orifice, so that when the sinus was split open 8 or 10 hairs 3 cm. long were seen lying in the tract but still rooted on the outside. We believe that in all these cases collection of loose hair in a pocket at the lower end of the scar, with eventual maceration of the skin and ulceration, was followed by the formation of a true sinus, at times running almost the whole length of the old scar, lined with inflammatory tissue and with small or extensive accumulations of loose hairs. In one of them the process was just beginning. The lower inch of the old scar, with a small pocket in it, was excised and the skin closed; in all the others the reoperation was more extensive and closure was not done. One patient had a recurrence that did not seem explicable in this way. He returned at one year with an abscess in the center of his old scar. There was no hair and no true sinus, and his wound healed in three weeks.

Ten per cent of the original 135 operations, therefore, were failures because of sepsis immediately after operation, while 13 of the 127 operations in patients who were followed for a year or more were failures from recurrence. Six of the wounds with major sepsis did heal without reoperation, but as closed procedures the operations must be considered failures since the patients lost more time (an average of 14 weeks) than they would have with an open operation.

Nineteen other patients had complications of a less serious nature, not regarded as a real failure of the procedure as they did not require reoperation and there was less loss of time than after open operation (the median healing time for the open operation in 53 cases here as well as in Rogers and Dwight's[2] series was nine weeks). Eight suffered minor wound sepsis in the hospital. The wounds healed with packing within four to eight weeks after the operation; six patients left with healed wounds but had minor imperfections in the scar, chiefly superficial sinuses (less than 5 mm. deep) caused by bridging of irregular skin edges. These could be laid open, without anesthesia, by a snip of the scissors and required no further treatment. In five cases one to three stitches sloughed at the lower end of the wound, which then healed again without event.

COMMENT

The criteria by which an operation for pilonidal sinus is judged are the healing time and the recurrence rate based on a follow-up of one year or more. With any

2. Rogers, H., and Dwight, R. W.: Pilonidal Sinus: Observations on 140 Cases Treated by Cautery Excision, Ann. Surg. **107**:400-418 (March) 1938.

type of closure the healing time in the successful cases will be between one and two weeks, but the healing time in the failures will vary with the extensiveness of the operation.

The rate of major failure in the hospital (10% of 135) and of recurrence (13% of 127) is not excessive for an operation that could be used for all but the most extensive lesions. However, the figures do not indicate the difficulties encountered in the 29 gluteal flap cases which were considered as major failures. In 80% of these the patients had to have reoperation, a few of them twice; the average healing time for the group was over 15 weeks, with some requiring six months. One wound was not wholly healed after five operations and 14 months of care. The loss of time to the patient is obvious. It is more difficult to assess the discomfort of a second operation and the inconvenience of a continuing open lesion before the second operation was done, but it seems that the 23% of patients whose operations were considered failures were paying too dearly for the time saved by the 63% who had perfect results and the 14% who had relatively good results.

Knowles and Baker [3] used a somewhat similar operation (that of Holman), in which flaps are mobilized by cutting the gluteal fascia at its insertion on the edge of the sacrum. In 187 cases they had a total rate of failure of 37% and have discontinued using the operation.

The pattern of recurrence described above is of great interest. The extensive excisions preclude the assumption that the recurrences are due to hair-producing epithelium being left after operation, and the size and location of the recurrences also indicate that they were of mechanical origin due to imperfections in the scar. We have seen similar recurrences after other types of closure in which the crease between the buttocks had been partly eliminated. We have also seen exactly the same type of sinus, with a great nest of hair, occur after posterior excision of the rectum in a patient who never had a pilonidal sinus. Similar recurrences on a smaller scale have been observed aften open treatment of pilonidal sinus with imperfect healing, in which an overhanging skin edge has formed the pocket that collected hair.

SUMMARY AND CONCLUSIONS

The technique, complications, and end results in 135 gluteal flap operations have been described.

The difficulties encountered in dealing with the failures and recurrences after an extensive plastic closure of this type have led us to the conclusion that the operation has no place in the treatment of pilonidal sinuses. We feel that the basis of this conclusion is valid and that reporting the observation is warranted in order to deter others from attempting similar procedures.

We believe that recurrences following pilonidal sinus operation are not due to persistence of hair-producing epithelium but are true recurrences due to mechanical factors, caused by collection of hair in an imperfect scar.

Our present program for the treatment of pilonidal sinuses consists in minimal excision and closure without plastic flaps in selected small midline lesions and open treatment in all other cases. Both of these methods will be reported in another paper.

3. Knowles, B. L., and Baker, W. J.: Marsupialization Operation for Pilonidal Sinus, New England J. Med. **245**:134-139 (July 26) 1951.

FRACTURES OF THE SHAFT OF THE TIBIA AND FIBULA

Comparative End-Results from Various Types of Treatment in a Teaching Hospital

EARNEST B. CARPENTER, M.D.
RICHMOND, VA.
JOHN J. DOBBIE, M.D.
HAGERSTOWN, MD.
AND
CHRISTIAN F. SIEWERS, M.D.
FAYETTEVILLE, N. C.

THE FOLLOWING report is an analysis of the end-results obtained in the treatment of fractures of the shaft of the tibia and fibula at the Medical College of Virginia Hospital, Richmond, Va., for the years 1947 and 1948 and the first six months of 1949. A total of 135 fractures in 123 patients were treated, 12 of the patients having suffered fractures of the lower part of both legs. Only fractures of the shafts of these bones are included in this study; fractures of the condyles, plateau, and malleolus of the tibia have been excluded. Only patients above the age of 10 years have been included in this study as it was not felt that such fractures in patients below the age of 10 years presented any particular treatment problems in general.

A teaching hospital, this institution receives a great majority of all accident and traumatic work in the area. Automobile and pedestrian accidents accounted for a large percentage of the cases included in this report. The Orthopaedic Service operates on a rotation basis with Board Member Orthopedists alternating on service for instruction and supervision of the Resident House Staff. The wide variety of types of treatment of these cases is representative of the differences of opinion of these orthopedists in the treatment of tibial-shaft fractures.

TYPES OF FRACTURES

The cases have been divided into five categories, namely, simple fracture; simple, comminuted fracture; compound fracture; compound, comminuted fracture; and compound, comminuted, multiple fracture. The last category includes those fractures of severe degree with fragmentation of the tibial shaft at several levels.

METHODS OF TREATMENT

Orthopedists treating fractures of the tibial shaft use a method or methods of reduction that produce the best results in their hands. A method that may give good results for one may be entirely unsatisfactory to another. We are not advo-

From the Department of Orthopaedic Surgery, Medical College of Virginia Hospital, Richmond, Va.

cating any particular type of treatment of these fractures in this report. The purpose of the paper is to analyze the end-results obtained from several different methods of treatment and to evaluate both good and bad results obtained. We do feel, however, that a great majority of these fractures can be treated by conservative measures with very satisfactory results. All fractures treated were handled as emergencies, and treatment and reduction were carried out shortly after the patients' admission to the hospital.

TABLE 1.—*Data on Patients with Fracture*

Total number of patients	135
Male	108
Female	27
White	73
Negro	62
Average age: 37 years	
Average hospital stay: 21 days	

TABLE 2.—*Types of Fractures*

Simple fracture	19
Simple, comminuted fracture	43
Compound fracture	1
Compound, comminuted fracture	75
Compound, comminuted, multiple fracture	9
Fracture of both lower legs	12
Gunshot wounds	5

Fig. 1.—Artist drawing of reinforced gauze traction hitch. The operator reduces the fracture and applies the lower leg part of the cast with the knee held straight by traction and counter-traction. The traction can then be partially relaxed and, with the knee flexed, the upper portion of the cast applied.

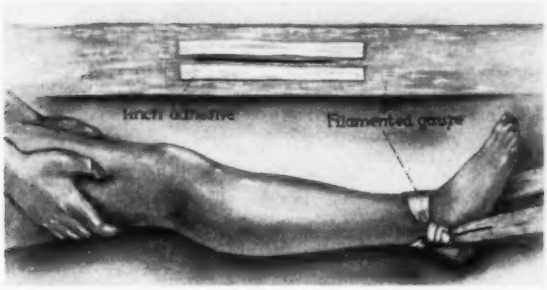


Fig. 2.—Artist drawing of close-up of gauze traction hitch. After the cast has hardened, the hitch can be easily removed by cutting the gauze bands on the outside of the leg just proximal to the circular strip of adhesive and pulling the hitch through from the inside of the leg.

Fig. 3.—Roentgenograms of simple fracture of tibia and fibula in a 74-year-old white woman. (*A* and *B*) on her admission. After closed reduction, clinical union occurred at 8 weeks and full weight-bearing at 10 weeks, and the patient was clinically asymptomatic. *C* shows roentgenograms at the end of eight weeks.

Closed Reduction.—By closed reduction we mean reduction of the fracture by means of traction applied to the ankle, using a reinforced gauze traction hitch as originally described by Wilson and modified by Mauck [1] (Figs. 1 and 2). Traction is applied by an assistant while the operator reduces the fracture and applies the cast.[1] This is an old method of treatment which is simple in its application and requires no elaborate outlay of traction equipment. This method can be used effectively without general anesthesia. We have a strong belief that firm immobilization of the fractured leg is essential for a good result, regardless of the method of treatment employed. We further believe that regardless of whether the fracture is treated by open or closed methods, the application of a snug-fitting plaster cast with a minimum of sheet wadding is the most important part in the treatment of tibial shaft fractures. By using the gauze traction hitch, firm, snug-fitting casts can be applied, with good immobilization of the reduced fracture and, most

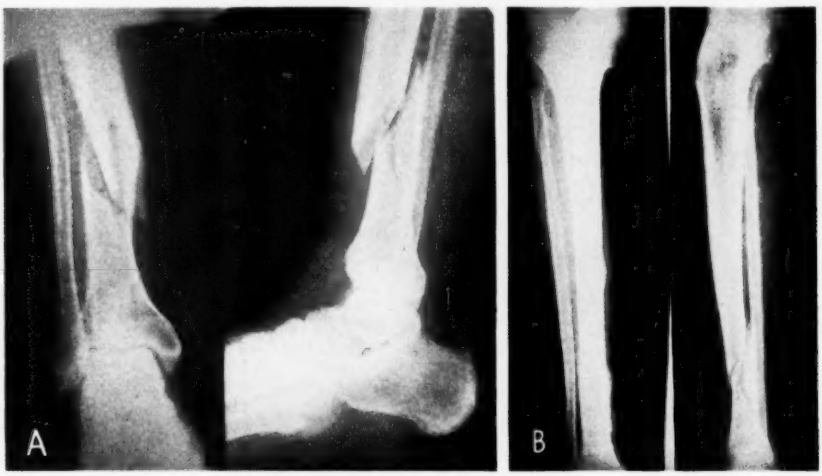


Fig. 4.—Compound, comminuted, spiral fracture of lower right tibia and upper fibula in a 74-year-old Negro. *A*, roentgenograms on admission. Patient also had fracture of pelvis and right radius and ulna. Débridement and closed reduction of tibia were carried out, with immobilization for 25 weeks and full weight bearing at 30 weeks. *B*, roentgenograms at the end of 25 weeks. Patient returned to work as a laborer.

importantly, maintenance of the reduction throughout the period of immobilization. All casts were routinely split from the base of the toes anteriorly to just below the knee to allow for edema after reduction. The injured leg was then elevated on a fracture box and ice bags applied to both sides of the leg. Sixty-one fractures in this series were treated in the above manner (Fig. 3).

Débridement and Closed Reduction.—Compound tibial-shaft fractures present an entirely different treatment problem than do simple fractures. Not infrequently the compound soft-tissue wound will in itself be as big a problem as the underlying fracture. Preservation of all viable tissue, particularly skin, with soft-tissue cover-

1. Mauck, H. P.: Treatment of Fractures of Both Bones of the Leg by Conservative Methods, South. M. J. **36**:609-613 (Sept.) 1943.

Fig. 5.—Compound, comminuted fracture of tibia and fibula in a 42-year-old Negro. *A*, roentgenograms on admission. Débridement and closed reduction. Immobilization for 13 weeks. *B*, roentgenograms at the end of 13 weeks. One-half inch (1.27 cm.) shortening of leg. Full range of motion of knee and ankle.

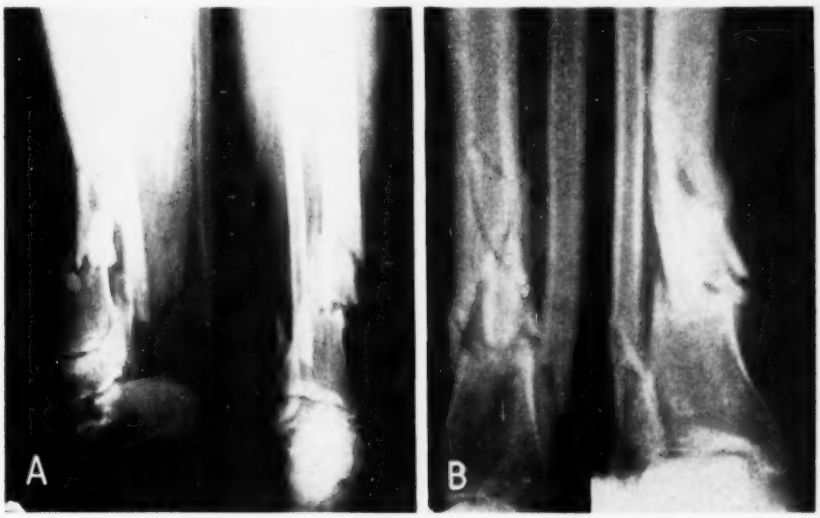


Fig. 6.—Compound, comminuted fracture of tibia and fibula in a 64-year-old Negro. *A*, roentgenograms on admission. Débridement and closed reduction. Immobilization for 16 weeks. Full weight bearing at 18 weeks. Patient returned to work involving heavy labor, clinically asymptomatic. *B*, roentgenograms at the end of 16 weeks

age of all bone is the first consideration in the treatment of these fractures. Fifty-one fractures in this series were treated by débridement of the compound wound followed by a closed reduction of the fracture using the gauze traction hitch (Figs. 4, 5, 6, and 7). In each instance the soft-tissue wounds were thoroughly débrided and the skin edges approximated with interrupted silk sutures. No attempt was made to reduce the fracture under direct vision, but rather the fracture itself was reduced by traction and closed manipulation. All patients were placed on antibiotic therapy until the temperature had been normal for 72 hours. Tetanus antitoxin or toxoid was administered routinely on their admission.

Open Reduction Without Internal Fixation.—In 11 cases in this series an open reduction of the fracture was performed without the use of any internal fixation. In each of these cases the fracture site was opened and the fragments reduced

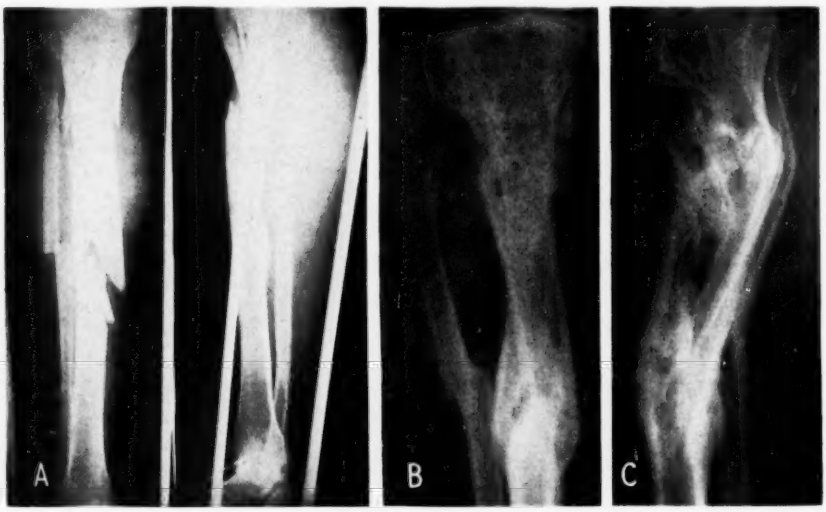


Fig. 7.—Compound, comminuted, multiple, severe fracture with extensive soft-tissue trauma in a 40-year-old white man. *A*, roentgenograms on admission. Amputation was considered on the patient's admission because of a questionable blood supply of the lower leg and foot. Débridement and closed reduction were performed and delayed union occurred. Immobilization for 50 weeks. *B* and *C*, roentgenograms at the end of one year show minimal residual limitation of motion of knee and ankle. Patient returned to work as truck driver.

under direct vision. The operator in each instance felt that the fragments were so approximated that the use of any type of internal fixation was unnecessary. The operative wounds were then sutured and a long leg cast applied (Fig. 8).

Open Reduction and Internal Fixation.—Twenty-four fractures were treated by open reduction and internal fixation with some type of plate, screw, or wire. The type of internal fixation used in these 24 cases is shown in Table 3. The wide variety of internal-fixation material used is, we believe, an expression of the differences of opinion of the various surgeons treating these fractures.

The use of internal fixation of tibial-shaft fractures by means of plating of the fibula is, of course, not new (Figs. 9 and 10). In our experience this method of

internal fixation of fractures of the lower leg has a great deal of value and is not as widely used as perhaps it might be. It is of particular value in compound tibial fractures with large soft-tissue wounds or actual loss of skin surface for which internal fixation of the tibia by plate or other methods might not be desirable.

MORTALITY

In this series of 135 fractures there were four deaths. One death was definitely attributable to the lower leg fracture in that thrombosis of the popliteal artery

TABLE 3.—*Methods of Internal Fixation*

5. Eggers-type contact plate	3
6. Catgut loop sutures	1
7. Plating of fibula	5
8. Double plating of fibula	1
1. Transfixion screws	3
2. Wire loop	1
3. Collison-type slotted plate	6
4. Double plating of tibia at two levels	2

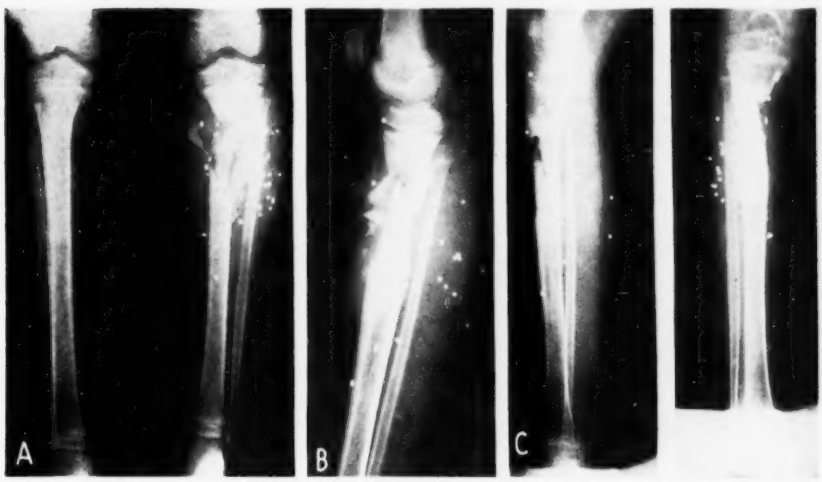


Fig. 8.—Gunshot wound with compound, comminuted fractures of tibia and fibula in a 12-year-old Negro boy. Extensive soft-tissue injury over wound of entrance. *A* and *B*, roentgenograms on admission. Débridement and application of split-thickness skin graft over skin defect anteriorly. Delayed union occurred, with immobilization for 32 weeks. Full recovery took place, without residual limitation of motion of knee or ankle. *C*, roentgenograms at the end of 32 weeks.

resulted in a massive infection of the leg, which necessitated a supracondylar amputation on the sixth day after injury. This patient died of generalized toxemia four hours after amputation, in spite of all supportive measures. Three of the patients died of other multiple injuries sustained at the time of the leg fracture. Two of these deaths were due to severe head injuries, and one was due to an extensive crushing chest injury.

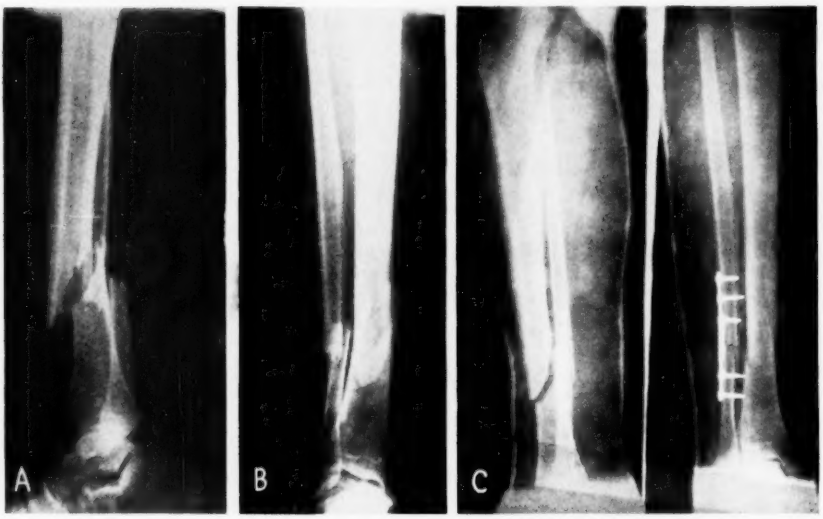


Fig. 9.—Compound, comminuted fracture of tibia and fibula with marked laceration of overlying tissue in a 48-year-old Negro. *A* and *B*, roentgenograms on admission. Débridement of compound wounds was carried out, and then open reduction of the fibula and internal fixation with a metal plate and closed reduction of the tibia were performed. *C*, roentgenograms after reduction. Clinical union took place at 15 weeks. Patient returned to work to do heavy labor, clinically asymptomatic.

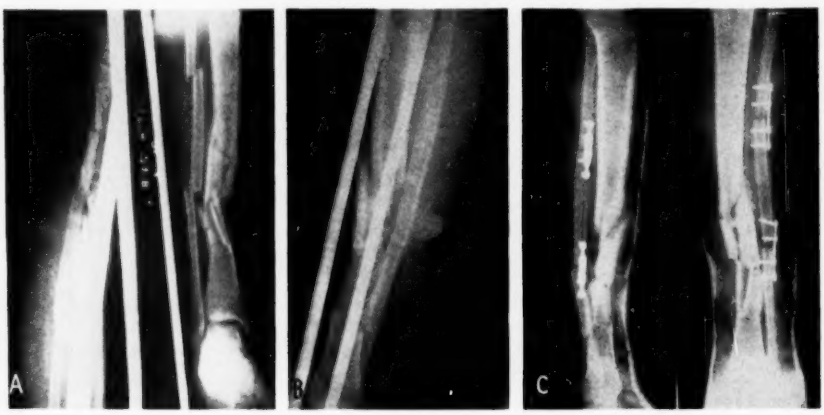


Fig. 10.—Compound, comminuted, severe fracture with extensive soft-tissue trauma over the medial aspect of the tibia in a 21-year-old Negro. *A* and *B*, roentgenograms on admission. Débridement of compound wounds was done, and open reduction of the fibula and internal fixation with metal plates at two levels and closed reduction of the tibia were carried out. *C*, roentgenograms after reduction. There was delayed union, with immobilization for 26 weeks. There was a good clinical result, and the patient returned to heavy work nine months after the fracture.

COMPLICATIONS

There were 10 cases of postoperative infection in this series. By postoperative infection, we mean infection with actual bony involvement. All the infections occurred in the compound fractures. Of these 10 fractures with osteomyelitis, 5 went on to firm bony union without further operative procedures. One required a sequestrectomy of the tibia two months after injury and then progressed to subsequent bony union. Two postoperative infections were due to gas-producing organisms and required supracondylar amputations within 10 days after injury. The remaining two cases of infection subsequently required amputation (below the knee) because of persistence of infection over a long period. Of the four cases of postoperative infection which subsequently resulted in amputation, three were cases of fracture of multiple extent with the tibia fractured at several levels. In all there was extensive soft-tissue trauma. The fourth case of postoperative infection, with subsequent amputation two years later, involved a comminuted fracture of the tibia and fibula in the middle third with only a relatively small compound wound.

AMPUTATIONS

There were nine amputations performed in this group of 135 fractures, or 6.06%. This is, admittedly, a high percentage of amputations for a relatively small group of cases, and an analysis of the causes for amputation is indicated. As stated above, four of the amputations were due to infection, two being due to gas-producing organisms with massive infection of the entire lower leg. The fractures in both of these instances were extensive and were accompanied with large compound wounds. In the first of these cases an open reduction of the fracture was done, with internal fixation of the tibia at one level with a Collison-type slotted plate. In the other case of gas infection, débridement of the compound wounds was performed, followed by a closed reduction of the fracture. Both patients were on antibiotic therapy after the definitive treatment. The definitive treatment in the third case of amputation necessitated by infection consisted in open reduction of the tibia and internal fixation of the tibia at two levels with Collison-type slotted plates. This patient also had a compound fracture of the femur on the same side. Both plates were subsequently removed because of infection, and a sequestrectomy was later done because of persistence of infection. The below-knee amputation was done 14 months after the original injury because of inability to control the infection of the lower half of the tibia. The treatment in the fourth case of amputation resulting from infection was open reduction of the fracture and internal fixation of the tibia with two obliquely placed transfixion screws. The infection in this case was resistant to all treatment, and amputation was finally done two years after the original injury because of extensive limitation of knee motion and residual osteomyelitis of the tibia.

In five cases amputation was done because of ischemic necrosis secondary to major vessel trauma. Four of these fractures were compound and comminuted, with associated moderately severe compound wounds. The remaining amputation, resulting from ischemic necrosis, was in a case of severly compound, comminuted fracture with the tibia fractured at three levels. This patient also had a comminuted fracture of the femur on the same side, and it is believed that the resultant throm-

bosis of the popliteal artery with extension into the anterior tibial artery was unquestionably due to the extensive trauma to the entire leg. The fracture of the tibia was treated by débridement of the wounds and closed reduction of the fracture. The femur was treated by skeletal traction using a supracondylar Kirschner wire. In this case evidence of vascular trauma became evident on the ninth day, but in spite of paravertebral sympathetic blocks and anticoagulant therapy, ischemic necrosis progressed, and a supracondylar amputation was necessary on the 18th day. Of the five cases of amputation due to vascular trauma, only one actually had severance of a major vessel. In the remaining four thrombosis of a major artery developed in from three to five days after treatment of the fracture. The case of severance of the anterior tibial artery involved a compound comminuted fracture of the lower third of the tibia, with very little soft-tissue trauma. A dorsalis pedis pulsation was not present on the patient's admission to the hospital. The fracture was reduced very well by a closed reduction and immobilized in a long leg plaster cast. Continuous caudal anesthesia was started the following morning and maintained for 48 hours, but the level of ischemic necrosis progressed and demarcated just proximal to the fracture site. A below-knee amputation was necessary on the sixth day. Dissection of the amputated lower leg revealed division of the anterior tibial artery at the level of the fracture. In retrospect, this case likely would have

TABLE 4.—*Secondary Operations*

Removal of tibial bone plate	2
Removal of tibial transfixion screws	1
Sequestrectomy	1
Bone graft for nonunion	5
Osteotomy for malposition	1

benefited had exploration of the anterior tibial artery been done on the patient's admission. A review of the roentgenograms in these five cases revealed that the reduction of the fracture was satisfactory in each instance. All the fractures were of severe degree, and undoubtedly some vascular trauma was sustained at the time of the injury which resulted in subsequent arterial thrombosis.

ANALYSIS OF RESULTS OBTAINED

Of the total of 135 fractures, we were able to obtain the end-result in 126. In nine of this number amputations were performed, leaving a total of 117 fractures for which the end-result could be evaluated. The length of time of immobilization was obtained in each instance, but in an attempt to arrive at the average length of immobilization so many variables were encountered that we do not feel that this average period of immobilization would be of any statistical value. Rather, we have attempted to analyze the causes of delayed union, nonunion, postoperative infection, and amputation in the light of the method of treatment used. The cases resulting in amputation and postoperative infection have been reviewed above. Table 4 shows the secondary operations necessary in this group of cases.

Nonunion.—Nonunion developed in six cases, one of which, described above, resulted in a below-knee amputation two years after the original injury. In the five remaining cases of nonunion subsequent bone-graft surgery was carried out to

repair the nonunion present. In all five of these cases subsequent firm healing of the fractures took place.

Delayed Union.—For the definition of delayed union we have arbitrarily set the dividing line at five months. Those cases in which there was not sufficient union at the end of five months to permit weight bearing without support were classed as instances of delayed union. There were 22 cases in this category, all of which subsequently progressed to firm bony union. In a review of these 22 cases of delayed union it was revealed that compound fractures were present in 18. The type of treatment rendered in these 22 cases of delayed union is shown in Table 5.

As stated above, all 22 patients with delayed union subsequently acquired firm bony union without additional surgery. The longest period of immobilization of any of these fractures was 50 weeks (Fig. 7). Six of the patients with delayed union had fractures of both lower legs, all of which were compound. We believe that it is reasonable to assume that the occurrence of delayed union in these cases was associated with the extensiveness of the multiple fractures and with the inability to employ the use of short leg walking casts at any time during the period of immobilization. It is interesting to note further that of the 10 cases of postoperative

TABLE 5.—*Treatment in Cases in Which Delayed Union Developed*

Open reduction without internal fixation	2
Open reduction with internal fixation:	
Collison-type slotted plate	1
Eggers contact plate	1
Transfixion, Kirschner wire	1
Fibular plate	2
Wire loop	1
Closed reduction	2
Débridement, closed reduction	12

infection mentioned previously nonunion developed in 2 and delayed union developed in five.

The following is a breakdown of all cases in the five groups (Table 2) and the results obtained by the various types of treatment.

Simple Fracture (19 Cases).—Eighteen of these fractures were treated by closed reduction followed by the application of a long leg plaster cast. All 18 healed without complications, the longest period of immobilization being 12 weeks. The remaining simple fracture had an open reduction and internal fixation with two transfixion Kirschner wires. There was a postoperative infection for three weeks which subsided with the use of antibiotics. This patient's leg was immobilized for 22 weeks with eventual full recovery without disability.

Simple, Comminuted Fracture (43 Cases; No Follow-Up in Six Cases).—All 43 of these fractures were treated by closed reduction and long leg plaster casts. Of the 37 patients in this category who were adequately followed up, 27 recovered without complications, the longest period of immobilization being 19 weeks. In five cases a delayed union developed, the longest period of immobilization being 36 weeks. Two cases went ahead to nonunion and required onlay tibial bone grafts at five and six months, respectively, with eventual solid bony union in both cases after bone grafting. Three patients in this series died, two as a result

of associated injuries and one as the result of a gas-producing infection of the opposite leg, which was a severely compounded fracture.

Compound Fracture (One Case).—In this case treatment was by débridement and closed reduction. The facture healed solidly in nine weeks without complications.

Compound, Comminuted Fracture (75 Fractures in 65 Patients).—There was no follow-up in four cases, leaving 71 in which satisfactory follow-up observations were made. In five of these cases gunshot wounds were present. Seven fractures were treated with open reduction without internal fixation. Of these seven, four healed solidly without complications. In the remaining three cases postoperative infections were present, in two of which delayed union developed. All three of the latter cases went ahead to eventual firm healing without subsequent surgery. In two cases open reduction and internal fixation with transfixion screws were carried out. In one of these solid union had occurred at 20 weeks. In the other case a persistent osteomyelitis developed which drained for nearly two years, and subsequently a below-knee amputation was performed because of inability to control infection and because of marked limitation of motion of the knee and ankle. Two fractures were treated by débridement of the compound wounds and internal fixation of the fibula. In both of these cases there was delayed union, but firm healing took place without subsequent surgery. One patient underwent open reduction and internal fixation with a wire loop. In this case also there was delayed union for 32 weeks, with marked limitation of motion of the knee. One patient underwent open reduction and fixation with two transfixion Kirschner wires. This patient also had a delayed union for 28 weeks, but with eventual firm bony union. Eight patients underwent open reduction and internal fixation with a Collison- or Egger-type slotted plates. In four of these the fracture healed solidly in 18 weeks or less without complications. Two patients had delayed union, the longest period of immobilization being 30 weeks. Both of these had subsequent firm bony union. In one nonunion developed, requiring an onlay tibial graft six months after the fracture. In one case a gas infection developed, with resultant amputation on the sixth day. The patient died four hours after amputation of generalized toxemia. The remaining 51 patients in this category were treated by débridement of the compound wound and closed reduction of the fracture. Thirty-five of these had firm bony union in less than five months without subsequent surgery or complications. Five patients in this category required amputation within 10 days after their original injury, three because of avascular necrosis and two because of gas-producing infections. In one of the cases of amputation because of ischemia, as mentioned previously, a division of the anterior tibial artery was carried out at the level of the fracture. In six cases there was delayed union, but in all subsequent firm bony union occurred, the longest period of immobilization being 36 weeks. In three nonunion developed, with subsequent onlay grafts at five, six, and eight months, respectively. All of these had firm bony union after bone grafting. Of the two remaining patients in this category, one had suppurative osteomyelitis for four weeks, with subsequent sequestrectomy and full-thickness skin graft. Bone healing was solid at five months without further surgery. The remaining patient had solid bony union at three months but, because of angulation and poor weight-bearing line through the ankle, required a corrective osteotomy one year later.

Compound, Comminuted, Multiple, Severe Fracture (Nine Cases).—In this last category are those patients with fractures of the shaft of the tibia and fibula of extensive and severe degree, with the tibia fractured at several levels. All such patients had extensive soft-tissue trauma of the lower leg. There were nine cases in this group, with one death, occurring on the 18th day and being due to severe cerebral trauma. Débridement and closed reduction of the tibial fracture were done in this instance. At the time of death the compound wounds were healed without evidence of local infection. Of the remaining eight patients, four were treated by débridement of the compound wounds, followed by closed reduction of the fractures. In one of these ischemic necrosis of the lower leg developed and the patient required a below-knee amputation on the 18th day. One patient had an uneventful recovery, with firm bony union in 16 weeks. The two remaining patients treated by débridement and closed reduction had delayed union, the longest period of immobilization being 50 weeks (Fig. 7). Both of these eventually acquired good functional results in spite of the long period of immobilization. Two patients in this group had open reduction of the fracture with internal fixation of the tibia at two levels with Collison-type slotted plates. One of these patients also had a compound fracture of the femur on the same side. In this case an extensive osteomyelitis developed in the tibia, which finally necessitated a below-knee amputation 14 months after injury. In the interim the bone plates had been removed because of massive infection. Soft-tissue trauma in this case was extremely severe, and in retrospect it is believed that this patient would have been saved many months of hospitalization had a below-knee amputation been done as a primary definitive measure. The other patient treated by internal fixation with a metallic plate also had severe osteomyelitis, but the fracture went on to firm bony union in 22 weeks. The plates were removed at the end of 12 weeks. This patient still has an occasional flare-up of localized osteomyelitis which responds to antibiotic therapy, but he has returned to his work as a motorcycle police officer. One patient was treated by débridement of the compound wound and internal fixation of the fibula at two levels with regular-type Collison plates. Immobilization lasted for 24 weeks, with solid bony union being obtained. The patient has returned to work involving heavy labor (Fig. 10). The last remaining patient had the fracture treated by open reduction without internal fixation. In this case nonunion developed and required an onlay tibial graft at 40 weeks. The fracture sites healed solidly after bone grafting. This patient also had a compound fracture of the opposite leg and a compound fracture of both forearms. The multiplicity of fractures undoubtedly contributed to the nonunion of the tibia and also the nonunion of one of the forearms.

COMMENT

We believe that a review of the above fractures of the shaft of the tibia and fibula revealed many significant facts. Unquestionably, many different interpretations of the results obtained can and will be made by others reading this report, but it is our impression, after a careful study, that the best results were obtained in patients who received the simplest type of treatment. The severe degree of trauma not only to bone but also to soft tissue in many of the cases, we believe, contributed the major causes for the development of complications. In many of the cases with severe soft-tissue trauma the treatment of the compound wound

was a greater problem than treatment of the fracture itself. Firm immobilization of the fracture beneath the compound wound is essential for the healing of the wound. It is our opinion now that the more extensive the compound wound the greater is the indication for internal fixation of the underlying fracture. We believe that there is only an occasional indication for open reduction and internal fixation of simple tibial-shaft fractures. But most important of all in the treatment of these fractures, in our opinion, is the application of a firm snug-fitting cast with a minimum of sheet wadding. This can be done effectively in the great majority of cases by the use of the gauze traction hitch (Figs. 1 and 2).

401 Medical Arts Building.

ANTERIOR HERNIATION OF A RUPTURED LUMBAR INTERVERTEBRAL DISK

Comments on the Diagnostic Value of the Diskogram

RALPH B. CLOWARD, M.D.
HONOLULU, HAWAII

THE TRAUMATIC rupture of a lumbar intervertebral disk with posterior herniation of portions of the disk into the spinal canal has long been recognized as the cause of the clinical syndrome characterized by low back pain and unilateral sciatica.[1] Operations for such conditions as "ruptured disk," "slipped disk," or "herniated nucleus pulposus" have become in recent years even commoner and more frequently encountered than appendectomies in many hospitals throughout the country. Surgical treatment for the disk syndrome, however, is seldom recommended without objective evidence of nerve root involvement, manifest by sciatic radiation, intensification on movement of the spine, sensory disturbance, and diminished reflex activity at the ankle. In the majority of cases these findings are considered essential criteria for the recommendation of surgery.

Little attention has been given to the possibility of surgical treatment for a ruptured lumbar intervertebral disk which has not herniated into the spinal canal. The early description by Dr. Walter Dandy [2] of the condition which he referred to as a "concealed disk" has been given little consideration. The reason for this is that surgeons did not have objective evidence to convince themselves of the presence of a pathological process. When the old reliable examination of myelography failed to disclose a lesion encroaching on the spinal canal and when objective clinical findings were absent, there was naturally a reluctance to advise surgery.

It has been the experience, however, of every neurosurgeon who has treated the ruptured disk that the majority of patients having this condition give a history of intermittent, incapacitating backaches, often for years, before the development of tell-tale sciatica.[3] Almost daily we see patients complaining of severe low back pain, intensified by heavy lifting, bending or just walking, who on examination have no objective signs of an abnormal condition of the lumbar region of the spine. These patients are often able to move freely in all directions without apparent discomfort. There is no evidence of muscle spasm, no radiation of pain into the lower extremities, and no positive neurological signs to indicate nerve-root pres-

1. Dandy, W. E.: Loose Cartilage from Intervertebral Disk Simulating Tumor of the Spinal Cord, Arch. Surg. **19**:660-672 (Oct.) 1929. Mixter, W. J., and Barr, J. S.: Rupture of the Intervertebral Disc with Involvement of the Spinal Cord, New England J. Med. **211**:210 (Aug. 2) 1934.

2. Dandy, W. E.: Concealed Ruptured Intervertebral Disks, J. A. M. A. **117**:821-823 (Sept. 6) 1941.

3. Spurling, R. G., and Bradford, F. K.: Neurologic Aspects of Herniated Nucleus Pulposus at the Fourth and Fifth Lumbar Interspaces, J. A. M. A. **113**:2019-2022 (Dec. 2) 1939.

sure. For years they have been pushed aside as malingerers or neurotics or have been treated with diathermy treatments, vitamin B injections, adhesive plastering, or back braces.

Likewise, most physicians who treat this condition have had the experience of seeing a patient return months or years later with acute sciatica and, on referring to an old office history card, have concluded that he probably had a ruptured disk all the time but that it has just now herniated into the spinal canal and manifested its presence objectively.

Fig. 1.—Normal diskogram. Dye confined to nucleus pulposus. A 24-year-old laborer complained of low back pain following a strain from heavy lifting. Examination gave negative results. The diagnosis was malingering.

For many years neurosurgeons have been hoping to find some objective diagnostic procedure by which the presence of a ruptured intervertebral disk could be detected in the absence of objective signs. If such an examination could be made, many patients could be operated on early and could be saved months or years of backache resulting in partial disability or loss of work, time, and money.

A diagnostic procedure which fulfills these expectations was introduced in 1950 by Dr. K. Lindblom, of Stockholm, Sweden, who demonstrated it in several neurological clinics throughout the United States. The procedure involves mak-

ing what has been called a diskogram. It consists of a direct puncture of the intervertebral disk through the spinal canal (a regular lumbar puncture) and the injection of a water-soluble radiopaque substance into the disk proper. Only 0.5 cc. of the opaque material, usually iodopyracet solution (35% diodrast®), can be forcibly injected into a normal intervertebral disk. The x-ray study demonstrates the dye confined to the small spherical-shaped, centrally placed nucleus pulposus (Fig. 1). If, however, the disk has been ruptured, with a complete tearing and disorganization of the fibers of the annulus fibrosus and collapse of the disk, 2 or 3 cc. of dye or more can be injected into the disk with ease. The x-ray studies demonstrate the dye diffused throughout the intervertebral space (Fig. 2). If the posterior fibers of the annulus fibrosus have been torn, some or all of the dye will be seen in the epidural space lying along the anterior wall of the spinal canal.

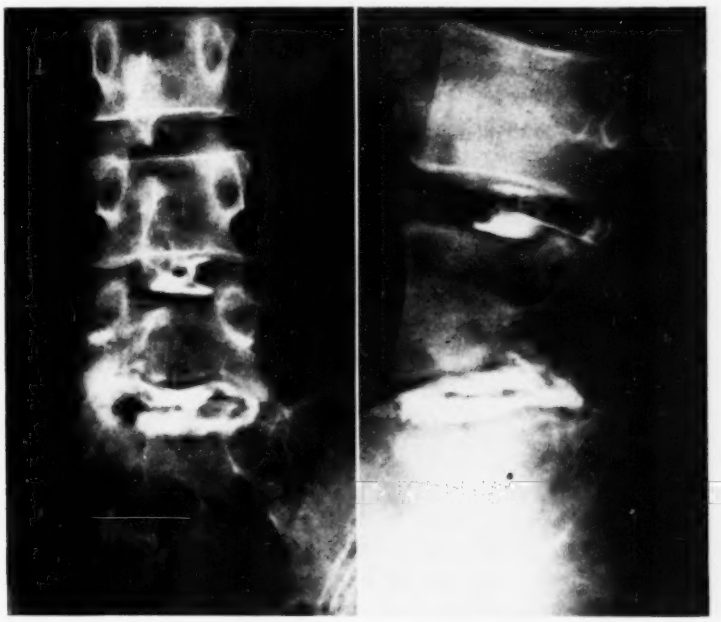


Fig. 2.—Abnormal diskogram. Dye fills entire lumbosacral interspace. There were complaints of intermittent backache after heavy lifting. The diagnosis was ruptured disk, at the fifth lumbar and first sacral vertebrae, without herniation.

I began the diskogram procedure in November, 1950. The information gained from the several cases in which it has been carried out since that time has convinced me that this diagnostic procedure will revolutionalize the treatment of ruptured intervertebral disks! It has proved, beyond a question of a doubt, to fulfill all the qualifications which for many years we had hoped to find in a diagnostic procedure to determine unmistakably the presence of a ruptured intervertebral disk without objective signs. With only the patient's subjective symptoms of intermittent low back pain, the presence or absence of a lesion, which can be treated surgically, can now be definitely determined. It is not necessary to "guess" that the patient has a "concealed disk," as Dandy did.

Since 1943 I have been treating all ruptured intervertebral disks by completely removing the disk and replacing it with several full-thickness bone grafts removed from the crest of the ilium for the purpose of fusing the vertebral bodies.[4] Over 265 of these intervertebral fusions have been done to date (May, 1951). For this operation several special instruments have been devised. The most valuable of these is the self-retaining vertebra spreader.[5] With this instrument it is possible to increase the space between the vertebral bodies to almost twice the normal width. With this excellent exposure of the disk space and careful investigation of the intervertebral disk under direct vision, several interesting pathological conditions have been observed to explain the patient's symptoms. For example, the annulus fibrosus has been found to have been chewed up into numerous pieces, lying free in the intervertebral space and unattached to the vertebral bodies. One can visualize this mass of loose material shifting from side to side or from front to back, depending on the position of the lumbar region of the spine. This may account for the history often given by patients that after sitting in one position for a period of time, as when at a movie, they find considerable difficulty in straightening their back when they first stand on their feet. It may also explain why patients are often seen with marked scoliosis of the lumbar region of the spine accompanied with a pelvic tilt but no lumbar pain or muscle spasm. One can visualize all these loose fragments of disk material lying to one side of the intervertebral space, acting as a wedge to tilt the spine. Another interesting finding which has been encountered is a rupture of the cartilaginous plate. Fragments of disk have been removed from the interspace which contain a plaque of the cartilaginous plate as large as 1.5 cm. in diameter. When the origin of this disk fragment is investigated, it is seen actually to have torn from the attachments to the vertebral body. The cause of these cartilage tears has not been apparent.

In most cases, however, when the vertebral bodies are spread apart, one sees only an open empty space in the center of the disk with ragged edges of the "chewed up" annulus on either side of the interspace. Fulcher [6] has described a patient who had undergone a disk operation and in whom the center of the disk had been curretted out. This patient still had his sciatic pain after the operation but only on lying down in the horizontal position and was relieved immediately on standing! The empty space in the center of the disk, obliterated in the upright position, became a vacuum in the horizontal position and could be shown at surgery actually to suck the nerve root into the posterior (surgical) opening in the annulus!

With the advent of the diskogram diagnostic procedure, it has been interesting to study preoperatively the pathological state of the ruptured intervertebral disk and then verify it at operation. In a recent study a tentative diagnosis of an anterior herniation of a ruptured intervertebral disk was made from a diskogram. There was considerable debate, however, between the roentgenologist and me as to the possibility or existence of such a lesion. It has usually been considered an anatomical impossibility for a disk to herniate anterior to the vertebral body because of the

4. Cloward, R. B.: The Treatment of Ruptured Intervertebral Discs by Intervertebral Fusion: Report of 100 Cases, read before the Harvey Cushing Society, Hot Springs, Va., November, 1947 (unpublished).

5. This instrument is manufactured by Codman and Shurtleff, Boston.

6. Fulcher, O. H.: Personal communication to the author.

heavy tough anterior longitudinal ligament. In a recent report by Bradford,[7] however, a patient was described in whom there appeared to be a defect in the anterior longitudinal ligament through which a blunt curette, used to curette the interspace, had passed into the abdominal cavity. Iodopyracet solution (diodrast®) was injected into the intervertebral space at operation and roentgenograms taken immediately. These showed the dye in the abdominal cavity, lying anterior to the vertebral bodies. These two cases would suggest that congenital thinning or actual openings in the anterior longitudinal ligament may make the anterior or lateral protrusion of torn disk fragments more frequent than had been previously suspected and possibly even commoner than posterior herniations.

REPORT OF A CASE

J. F., a waiter 42 years of age, had complained of chronic low back pain for approximately one year. He dated his backache to an injury which he sustained while playing volleyball. The

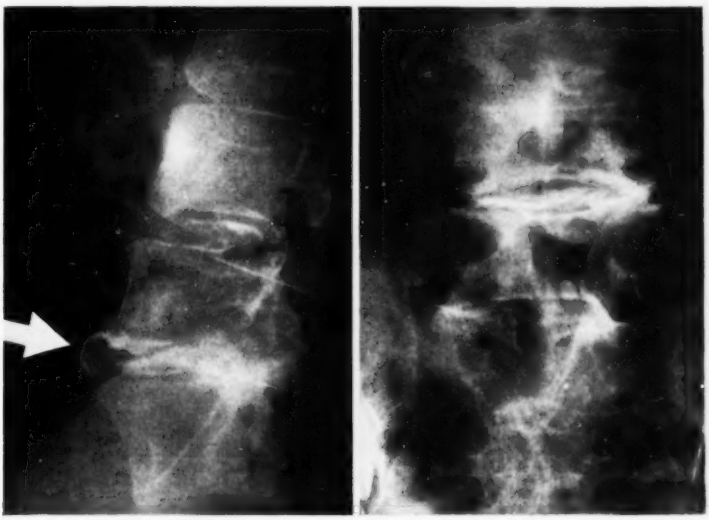


Fig. 3.—Diskogram demonstrating an anterior herniation of a large disk fragment. (See Fig. 4.)

patient made a high jump to strike the ball and came down stiff-legged. Immediately, pain developed in the lumbar area, which was so severe the following morning that he was unable to get out of bed. He was laid up for approximately two weeks. He continued to have a dull, nagging pain in his back, which was relieved by rest. He complained of some discomfort in the left posterior region of the thigh and calf muscle but did not describe it as a typical sciatic radiation. The neurological examination showed some limitation of movement of the lumbar spine in both flexion and extension. These movements, however, were not painful. The straight leg-raising test caused no discomfort. A vague decrease in sensation to light touch was demonstrated over the lateral surface of the left calf muscle, but the tendon reflexes in the ankle and knee were active and equal.

7. Leavens, M. E., and Bradford, F. K.: Ruptured Intervertebral Disc: Report of a Case with a Defect in the Anterior Annulus Fibrosa, read before the Harvey Cushing Society, Hollywood, Fla., April 28, 1951.

Because of the patient's subjective symptoms and history, he was thought to be a good candidate for a diskographic study. This procedure was carried out as described above. Approximately 0.5 cc. of diodrast® could be forced into the intervertebral disk between the fourth and fifth lumbar vetebrae. At the lumbosacral joint, however, 3 cc. of dye was easily injected. The patient complained of considerable pain in his back at the time of the injection, which he described as a pressure sensation. The pain disappeared within a half hour after the procedure.

The lateral roentgenograms of the lumbar spine after injection of the dye (Fig. 3) demonstrated a concentration of the dye in the center of the disk between the fourth and fifth lumbar vertebrae and no evidence of a rupture of the annulus fibrosus. At the lumbosacral disk, however, the dye was seen to fill the interspace and completely outline the central irregularity of the annulus, characteristic of a ruptured intervertebral disk. The interesting feature in the roentgenogram, however, was the presence of the diodrast® outlining the anterior longitudinal ligament. A thin line could be made out which was markedly convex, giving the appearance of the ligament being blown up like a balloon and protruding into the abdominal cavity. The

Fig. 4.—Specimen of loose fragment of disk removed from anterior part of intervertebral space.

diodrast® outlined in this manner what appeared to be a space-taking mass lying between the anterior edges of the adjacent vertebral bodies and protruding forward outside the intervertebral space. The roentgenogram was taken with the patient lying on his side with his spine markedly flexed, that is, with his knee pulled far up under his chin, the usual position for a lumbar puncture. In spite of this position, the anterior edges of the bodies of the fifth lumbar and first sacral vertebrae were seen to be spread wide apart as though they were held there by a wedge. From these interpretations of the diskogram, a preoperative diagnosis of an anterior herniation of the intervertebral disk was made.

The patient was operated on on May 16, 1951, and the usual extensive bilateral exposure of the anterior wall of the spinal canal was made in preparation for the interbody fusion. There was moderate bulging of the posterior annulus to the left of the midline, which may have accounted for the patient's complaints referable to the left leg. There was no defect in the posterior annulus, however. On removal of the posterior fibers of the annulus fibrosa and insertion of the vertebrae spreader, a careful investigation of the intervertebral space could be carried out under direct vision. A complete disruption and disorganization of the interior of the disk was found, and ragged edges of the annulus fibrosus were seen on either side of the disk space. Lying far anterior in the intervertebral space, a loose fragment of the disk was seen pro-

truding posteriorly. On grasping this with the disk rongeur, we were most surprised to withdraw an enormous fragment of the intervertebral disk (Fig. 4) lying completely free and unattached in the interspace, packed in a small wad and jammed forward between the anterior lips of the vertebral bodies. A small round depression in the thin anterior longitudinal ligament could be seen after the large fragment of disk material was removed. Although considerably thinned out, the ligament was not ruptured. The remainder of the intervertebral disk was then removed, including the cartilaginous plates and the cortical surfaces of the vertebral bodies, and three large full-thickness bone plugs, obtained from the bone bank, were driven into the intervertebral space to complete the interbody fusion. The patient made an uneventful recovery from the operation and returned to his employment as head waiter at the Royal Hawaiian Hotel three weeks after the operation. Follow-up roentgenograms of the spine three months later showed a solid vertebral body fusion and the patient was discharge as cured.

Comment.—This interesting finding of an anterior herniation of a ruptured intervertebral disk, diagnosed preoperatively by x-ray study and verified at operation, may throw some light on the failure of many patients to be cured of low back pain after the standard disk operation. It has been the practice of neurosurgeons for many years, and still is among the majority of them, to remove only the fragment of the intervertebral disk which has herniated into the spinal canal and compressed the nerve root, or perhaps, to curette, through a small opening in the annulus, a portion of the nucleus pulposus in the center of the disk. The "disk operation" as performed by me offers a wider exposure for a more thorough investigation of the intervertebral space under direct vision. The finding of a loose piece, or pieces, of torn intervertebral disk lying within the interspace and at times lying far anterior, as we found in the case described above, indicates the necessity of a more complete visualization of the disk. If the patient's back pain is to be cured and/or a recurrence of his sciatica prevented, a complete removal of these fragments is essential. A permanent cure of disability due to a ruptured disk may further be assured by using the procedure of fusing the vertebral bodies after complete removal of the intervertebral disk.

SUMMARY AND CONCLUSIONS

One of the chief causes for the poor results of operations for ruptured intervertebral disks is the failure to recognize and remove all the torn loose fragments of the ruptured disk from the intervertebral space.

A case is described in which a large fragment of torn disk was demonstrated preoperatively by x-ray study and verified at surgery to have herniated far anterior in the intervertebral space. In a standard disk operation, this loose piece of intervertebral disk would most likely have been missed.

The value of the diagnostic procedure using a diskogram in recognizing the presence of a ruptured disk in the absence of objective physical findings is described.

388 Alexander Young Building.

EFFECTS UPON THE LUNG OF VARYING PERIODS OF TEMPORARY OCCLUSION OF THE PULMONARY ARTERY

HARRY A. DAVIS, M.D.
WILLIAM B. GORDON, M.D.
EDWARD W. HAYES Jr., M.D.
AND
MALCOLM T. WASLEY, M.D.
LOS ANGELES

THE EXACT sensitivity of pulmonary tissue to ischemia is not known. The purpose of the present investigation was to determine the sensitivity of the lung to varying periods of ischemia produced by temporary complete occlusion of one pulmonary artery. Temporary occlusion of the pulmonary artery may be indicated in certain circumstances; for example, to control bleeding during partial resection of the lung or following injuries to the lung. The data which will be presented in this paper indicate that the lung is relatively less sensitive to ischemia than are many other tissues, notably the central nervous system and the heart.

MATERIALS AND METHODS

Monkeys (Macacus rhesus) were used. Ether anesthesia was administered by means of an intratracheal tube. All our observations were made on the left lung. In this way the technical procedures could be standardized. The left lung was exposed through an incision made over the left fifth rib. The left pulmonary artery was isolated and was occluded in such a way as not to injure the intimal lining. The periods of occlusion were 15 and 30 minutes, 1, 2, 3, 4, 8, 12, 48, 50, 93, and 168 hours. On completion of the period of occlusion, the animals were killed at intervals varying from 24 to 168 hours. The lungs were removed for microscopic examination. During the period of arterial occlusion, the chest was temporarily closed after the lung had been inflated. In a group of control animals sham operations were performed in which the pulmonary artery was isolated but not occluded.

RESULTS

The alterations in the lungs subjected to varying periods of occlusion of the pulmonary artery may be divided into (*a*) gross changes and (*b*) microscopic changes.

Gross Changes.—The gross changes, in general, consisted of reduction in size of the affected lung, which appeared to be slightly reddened and congested. These alterations were most noticeable 24 to 48 hours after completion of the period of occlusion (Fig. 1). Thereafter they gradually decreased in intensity. They occurred even with short periods of occlusion lasting 15 minutes. They increased in degree with the length of occlusion up to periods of two hours. Thereafter prolong-

From the Department of Surgery, College of Medical Evangelists, Los Angeles Division.

ing the occlusion period up to 48 hours did not seem to make the changes severer (Fig. 2). Beyond 48 hours of occlusion the gross pulmonary changes were very severe and consisted of varying degrees of infarction of the lung (Fig. 3).

Fig. 1.—Occlusion of left pulmonary artery for 2 hours (48-hour observation period). Note that left lung is smaller than right lung and shows reactive hyperemia.

Fig. 2.—Occlusion of left pulmonary artery for 48 hours (five-day observation period). Left lung has returned to its normal size but is still hyperemic compared with right lung.

Microscopic Changes.—In the control group of animals the left lung exhibited a few insignificant changes which were present in similar degree in the opposite intact lung. These consisted of slight congestion of the alveolar capillaries, occasional

areas of partial atelectasis, and minimal amounts of fluid in scattered alveoli (Fig. 4). In both the experimental and the control groups of animals the lingula of the left lung showed the severest changes.

Occlusion of the pulmonary artery for periods of 15 to 30 minutes produced minimal changes, consisting of slight distention of the alveolar capillaries and an increase in number of the macrophage cells. The period of observation in which the changes reached their maximum intensity appeared to be 48 hours. Accordingly, this was the time interval used unless otherwise stated. The right lower lobe was used for comparison in each animal.

One-Hour Occlusion: The pulmonary artery at the site of occlusion and its intrapulmonary branches exhibited no evidences of thrombosis. The left lung presented scattered areas of edema of the alveolar walls with edema fluid and red blood cells in the alveoli. In these areas numerous macrophage cells containing a

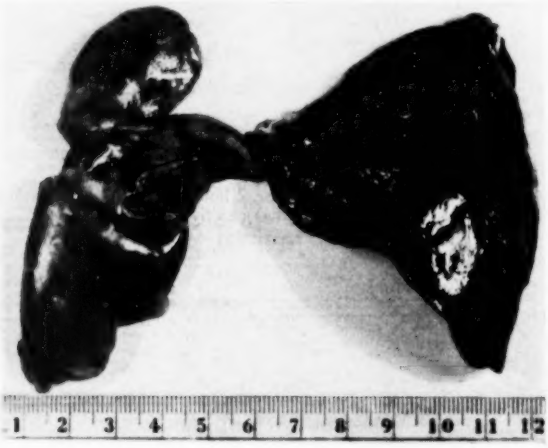


Fig. 3.—Occlusion of left pulmonary artery for 93 hours (72-hour observation period). Left lung shows hemorrhagic infarction.

brownish pigment ("heart failure" cells) were present. These alterations were greatest in the lingula, less in the lower lobe, and least in the upper lobe (Fig. 5). The right lower lobe showed no structural changes.

Two-Hour Occlusion: There was no thrombosis at the site of occlusion of the pulmonary artery or in its intrapulmonary branches. The chief change was atelectasis, which was most evident in the lingula. In addition, edema of the alveolar walls and "heart failure" cells were observed. The lower lobe of the right lung, however, exhibited scattered areas of edema and hemorrhage into the alveoli with numerous "heart failure" cells of a degree greater than that present in the left lung.

Four-Hour Occlusion: The pulmonary artery at the site of occlusion and in its intrapulmonary branches presented no thrombosis. Scattered areas of edema of the alveolar walls and edema of the alveoli with "heart failure" cells were noted in the left lung and were severest in the lingula, less severe in the lower lobe, and least severe in the upper lobe. There were changes in the right lung (lower lobe) which were similar in character and degree to those present in the left lung.

Eight-Hour Occlusion: There was no thrombosis of the pulmonary artery either at the site of occlusion or in the intrapulmonary branches. The changes in the left lung were scattered and consisted of edema of the alveolar walls, edema of the alveoli, which also contained "heart failure" cells, and congestion of the alveolar capillaries. The bronchial epithelium was intact (Fig. 6). These alterations were most evident in the lingula and least evident in the lower lobe. The right lung (lower lobe) exhibited changes similar in degree and in kind to those in the left lower lobe. When observed seven days after the period of occlusion, these changes had largely disappeared except in the lingula.

Twelve-Hour Occlusion: The pulmonary artery at the site of occlusion and in its intrapulmonary branches exhibited no evidence of thrombosis. The left lung

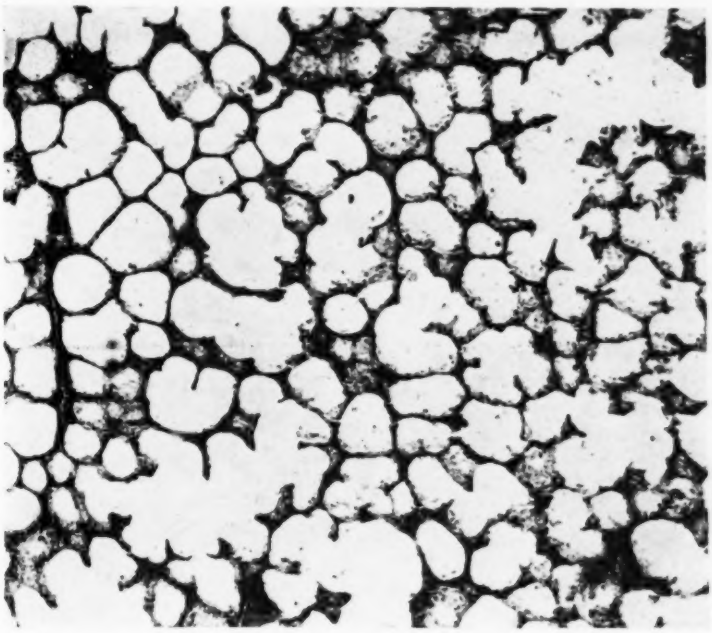


Fig. 4.—Left lung (× 95). Control group: minimal alveolar edema.

generally showed a tendency to partial atelectasis. This and other alterations, such as edema fluid and macrophage cells in the alveoli and edematous thickening of the alveolar walls, were most intense in the lingula, less so in the upper lobe, and least in the lower lobe. The bronchial epithelium was intact throughout. However, the right lung (lower lobe) exhibited changes which were similar in kind and equal in degree to those present in the left lower lobe. These changes gradually disappeared, so that after seven days the left lung was well aerated with only slight alveolar edema and atelectasis (Fig. 7). Nevertheless, the changes, particularly the edema, were still very evident in the lingula seven days later.

Forty-Eight-Hour Occlusion: The pulmonary artery at the site of occlusion was not thrombosed. The alveoli contained edema fluid with macrophage cells.

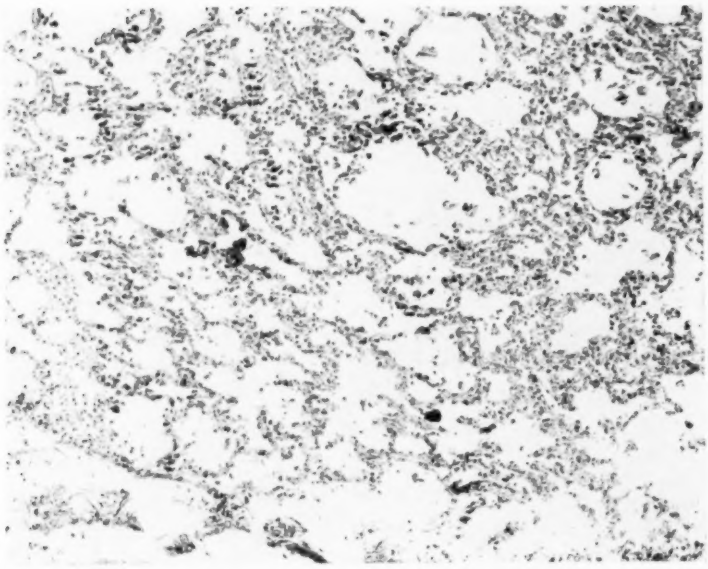


Fig. 5.—Left lung (× 95). Occlusion of left pulmonary artery for 1 hour (48-hour observation period). Alveoli contain macrophage cells.

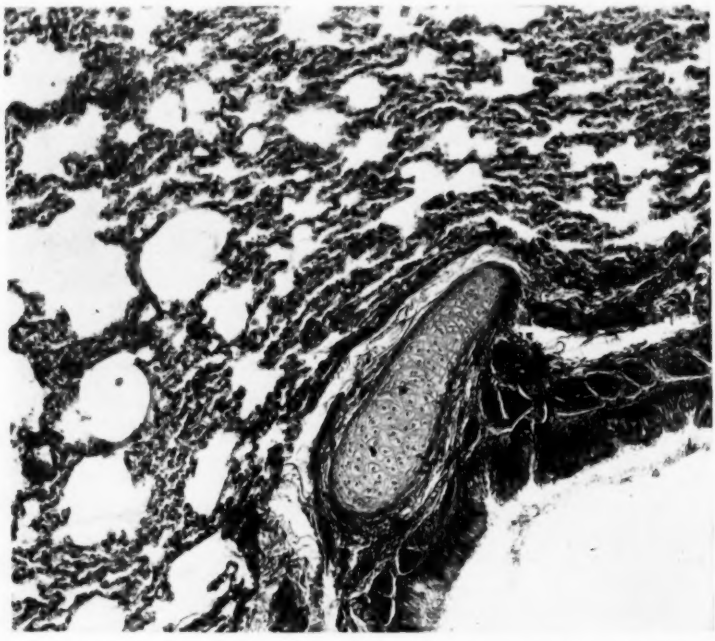


Fig. 6.—Left lung (× 95). Occlusion of left pulmonary artery for 8 hours (48-hour observation period). Minimal atelectasis and congestion of alveolar capillaries. Bronchial epithelium is intact.

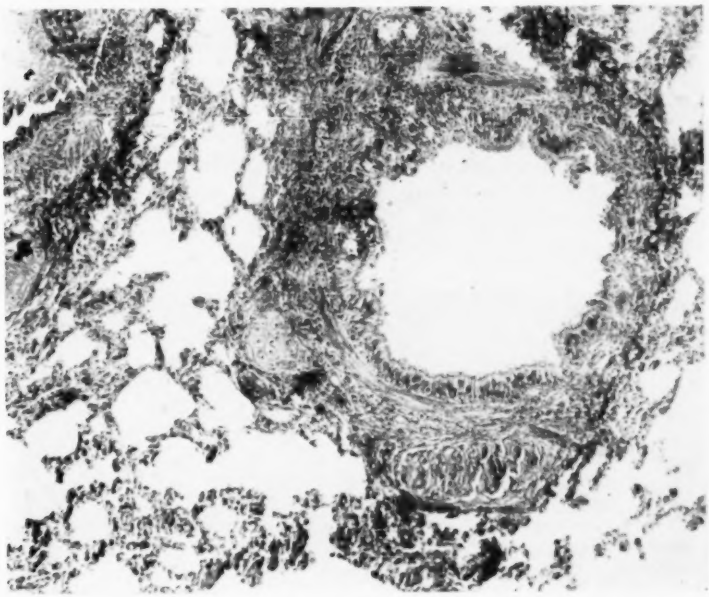


Fig. 7.—Left lung (× 95). Occlusion of left pulmonary artery for 12 hours (7-day observation period). Slight edema of alveolar walls and atelectasis. Bronchial epithelium is intact.

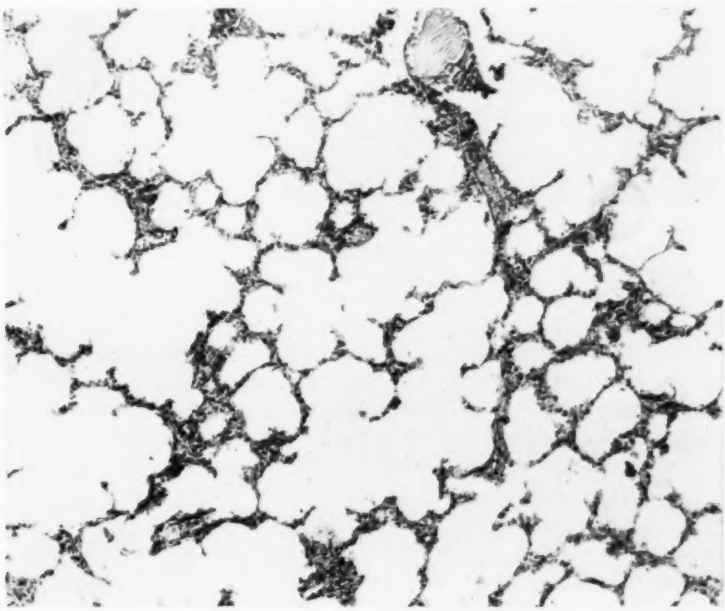


Fig. 8.—Left lung (× 95). Occlusion of left pulmonary artery for 48 hours (five-day observation period). Edema of walls of scattered alveoli. Note minimal changes.

The alveolar walls were edematous. These alterations were greatest in the lingula. Gradually the lung became more aerated, so that by the fifth day after occlusion the changes had largely disappeared except in the lingula, which presented histologic evidences of infarction. The bronchial epithelium was well preserved throughout the lung (Fig. 8).

Fifty-Hour Occlusion: There was definite thrombosis of the pulmonary artery at the site of occlusion and extending into the intrapulmonary branches. The lower lobe of the left lung was edematous, and hemorrhagic infarction of the lingula and upper lobe had occurred (Fig. 9). Pleuritis was present over the infarcted lobes. The right lung (lower lobe) presented no changes.

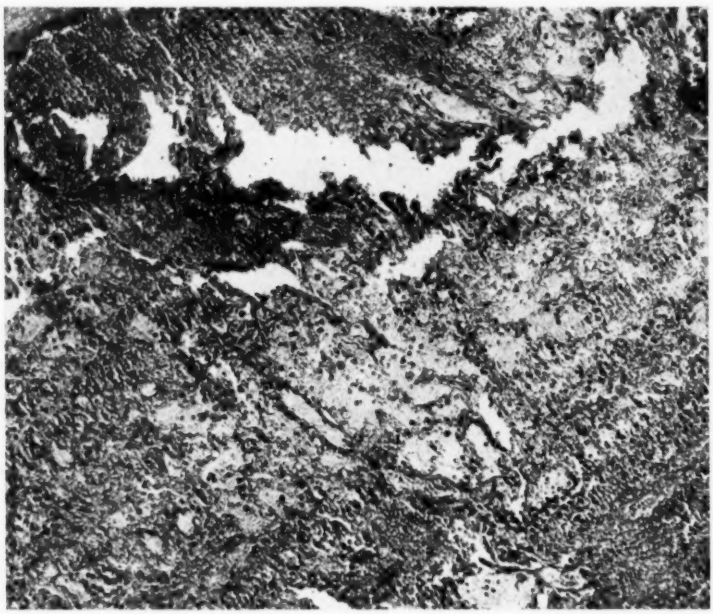


Fig. 9.—Left lung (× 95). Occlusion of left pulmonary artery for 50 hours (48-hour observation period). Extensive hemorrhagic infarction.

Seven-Day Occlusion: Thrombosis of the pulmonary artery and of its intrapulmonary branches was present. The entire left lung exhibited extensive hemorrhagic infarction with overlying pleuritis. The bronchial epithelium showed necrosis and was partially desquamated into the bronchial lumen. Curiously, the right lung (lower lobe) was not normal but exhibited signs of stimulation of the macrophage system, as shown by the presence of numerous macrophage cells in the lung. In addition, there was edema of the alveolar walls.

COMMENT

These results indicate that temporary complete occlusion of one pulmonary artery may be produced for periods up to 48 hours without causing irreversible structural changes in the ipsilateral lung.

It is pertinent to consider at this point the effect of permanent occlusion of the main pulmonary artery to one lung. When one pulmonary artery is permanently occluded, the corresponding lung becomes reduced in size (three-fourths to two-thirds of its normal size), and there occurs a slight fibrosis about the broncho-vascular rays and in the alveolar walls. The bronchial arterial channels become enlarged, and a collateral blood supply develops from the esophageal and other mediastinal vessels (pericardiophrenic vessels).[1] In the dog a lung with its main pulmonary artery ligated can maintain its respiratory function. At first its capacity to absorb oxygen is greatly reduced, but over a period of months this capacity gradually increases. The blood flow through the bronchial arteries of such a lung, as measured by means of the Fick principle, increases but takes a few months to reach its maximum.[2] There is some question regarding the presence or absence of electrocardiographic changes. Thus, Kisch and his co-workers[3] did not observe any changes in the electrocardiogram when one pulmonary artery was occluded. However, Semisch and Merves[4] reported that occlusion of the pulmonary artery incidental to pneumonectomy in 14 patients produced a shift of the electrical axis to the right in 71.4% and the appearance of a deep S wave in Lead I in 50%. These alterations manifested themselves immediately and disappeared within 24 hours. Brock[5] made direct estimations of the blood pressure in the main pulmonary artery of man before and after ligation of the pulmonary artery to one lung and could observe no change in the blood pressure. It seems, then, that evidences of right ventricular strain are present inconstantly when one pulmonary artery is ligated and disappear within 24 hours.

The mechanism of enlargement of the bronchial circulation is not clearly understood. It was first demonstrated by Virchow[6] that dilatation of the bronchial arteries occurred in chronic obstruction of the pulmonary artery to a lobe. This was confirmed by many subsequent investigators, for example, Mathes, Holman, and Reichert.[7] Injection studies indicate that the pulmonary and bronchial arterial

1. Schlaepfer, K.: Ligation of Pulmonary Artery of One Lung With and Without Resection of Phrenic Nerve, Arch. Surg. **9**:25-94 (July) 1924; Effect of Ligation of Pulmonary Artery of One Lung Without and With Resection of Phrenic Nerve, ibid. **13**:623-629 (Nov.) 1926. Penrod, K. E., and Hegnauer, A. H.: Effect of Pentothal Sodium on Blood Gas Transport, Am. J. Physiol. **153**:81-86 (April) 1948.

2. Bloomer, W. E.; Harrison, W.; Lindskog, G. E., and Liebow, A. A.: Respiratory Function and Blood Flow in Bronchial Artery After Ligation of Pulmonary Artery, Am. J. Physiol. **157**:317-328 (May) 1949.

3. Kisch, B.; Goldbloom, A. A., and Zucker, G.: Electrocardiographic Changes After Occlusion of Pulmonary Artery or Aorta, Cardiologia **6**:83-94, 1942.

4. Semisch, C. W., III, and Merves, L.: Electrocardiographic Studies on Artificially Produced Pulmonary Artery Occlusion in Human Beings, Arch. Int. Med. **69**:417-429 (March) 1942.

5. Brock, R. C.: Experiences in Pulmonary Artery Ligation, Guy's Hosp. Rep. **90**:217-229, 1940-1941.

6. Virchow, R., cited by Ghoreyeb, A. A., and Karsner, H. T.: A Study of the Relation of Pulmonary and Bronchial Circulation, J. Exper. Med. **18**:500-506 (Nov.) 1913.

7. Mathes, M. E.; Holman, E., and Reichert, F. L.: Study of Bronchial, Pulmonary, and Lymphatic Circulations of Lung Under Various Pathologic Conditions Experimentally Produced, J. Thoracic Surg. **1**:339-362 (April) 1932.

systems are independent normally but do have common capillary anastomoses.[8] These capillary anastomoses are also connected with the pulmonary veins.[9] It seems likely, as suggested by Ghoreyeb and Karsner,[10] that the increased flow through the bronchial arteries when the pulmonary artery is occluded is due to a fall in pressure within the capillary bed held in common by the two circulations. There is a lowering of the peripheral resistance to the bronchial arterial flow combined with a high pressure in the bronchial arteries transmitted from the aorta.

In the experiments reported here, the periods of occlusion of the pulmonary artery were relatively short, and, since the blood flow through the bronchial arteries takes several months to reach its maximum level, it seems very unlikely that the bronchial arterial circulation significantly decreased the ischemia resulting from obstruction of the blood flow through the pulmonary artery. Despite this, the lung is capable, according to our studies, of withstanding the ischemia produced by occlusion of the pulmonary artery for periods of at least 48 hours without undergoing irreversible structural damage. These observations indicate that pulmonary tissue possesses a considerable resistance to ischemic anoxia. This resistance is much greater than that possessed by the central nervous system, the heart, the kidneys, the liver, and the alimentary tube. The relative insensitivity of pulmonary tissue to ischemic anoxia may be due to the fact that the pulmonary arterial blood normally contains a low oxygen content and tension to which the pulmonary tissue has adapted itself. If this is true, it is reasonable to suppose that the lung would be more capable of withstanding ischemic anoxia than would a tissue normally supplied with arterial blood containing larger amounts of oxygen, for example, the nervous system.

It is necessary to explain the structural changes in the lung after temporary occlusion of the pulmonary artery. The following factors may be etiologically significant:

1. Intermittent positive-pressure anesthesia. This may explain the minor changes noted in the lower lobe of the left lung and in the intact right lung. It would not explain the severer structural alterations which were observed in the upper lobe and lingula of the left lung.

2. Ischemic anoxia. It has been suggested that the lung normally possesses considerable resistance to anoxia. Nevertheless, this does not mean that the lung is not subjected to some degree of anoxia when its main pulmonary artery is occluded. We have drawn attention to the evidences of stimulation of the macrophage system in the lung. This stimulation of the pulmonary macrophage cells occurs under conditions of reduced blood flow through the lungs.[11] Thus, it is observed consistently in congestive heart failure and in other conditions associated with a reduction in the output of blood from the heart, such as shock.[11] In the

8. Miller, W. S.: Vascular Supply of Bronchial Tree, Am. Rev. Tuberc. **12**:87-94 (Oct.) 1925.

9. Berry, J. L., and de Burgh Daly, I.: Relation Between Pulmonary and Bronchial Vascular Systems, Proc. Roy. Soc., London, s. B **109**:319-336 (Dec. 2) 1931.

10. Ghoreyeb, A. A., and Karsner, H. T.: A Study of the Relation of Pulmonary and Bronchial Circulation, J. Exper. Med. **18**:500-506 (Nov.) 1913.

11. Davis, H. A.: Shock and Allied Forms of Failure of the Circulation, New York, Grune & Stratton, Inc., 1949.

present experiments the increase in the number of macrophage cells may be attributed to ischemic anoxia and to the presence of red blood cells which have passed out of the altered capillaries into the alveoli.

3. Reactive hyperemia of the lung. When the pulmonary artery is occluded for a short period, there is some, but probably not much, increase in the bronchial arterial flow into the lung. This augments to some extent the alveolar capillary pressure which had been lowered by the obstruction to the pulmonary arterial blood flow. Restoration at this time of the flow through the pulmonary artery causes a reactive hyperemia in the lung and a sudden and rapid increase in pressure within the alveolar capillaries to a level at which the hydrostatic pressure greatly exceeds the osmotic pressure of the blood. As a result of this, there occur congestion of the alveolar capillaries, with passage of serum and red blood cells into the alveolar walls and into the alveoli, and congestive atelectasis. The longer the obstruction to the pulmonary artery, the greater will be the expansion of the bronchial arteries and the greater will be the flow from the bronchial arteries into the alveolar capillaries. The greater the flow from the bronchial arteries into the capillaries, the more deleterious will be the effect of release of the pulmonary arterial flow into capillaries which are already filled with blood.

Periods of occlusion of the pulmonary artery up to 48 hours are followed by reversible changes in the affected lung. However, if the occlusion lasts 50 hours or longer, the bronchial arterial flow into the capillaries is greater, and disocclusion after this time of the pulmonary artery is associated with widespread severe changes in the lungs. The end-point apparently lies somewhere between 48 and 50 hours in the monkey (Macacus rhesus). It is possible that the effect of release of an obstruction of the pulmonary artery upon the pulmonary tissue may depend upon the rapidity of removal of the excess blood in the capillaries by the pulmonary veins. The severe alterations occurring in the lingula of the left lung, as observed in these studies, may be explainable on this basis, namely, relatively inadequate venous drainage.

The clinical applications of these observations must now be considered. Permanent ligation of one pulmonary artery has been performed in the human being, leaving the lung *in situ*. Thus, it has been carried out for severe hemoptysis.[12] Brock[5] has probably had the largest individual experience with ligations of the pulmonary artery (18 cases). In all these reports the artery was permanently ligated, and, therefore, the effects produced by reestablishing the pulmonary arterial flow were not encountered. Temporary occlusion of one pulmonary artery may be required in the following circumstances: (1) during partial resection of the lung in order to control hemorrhage; (2) in the control of bleeding from the lung as a result of traumatic injuries; (3) during surgical division of the patent ductus arteriosus.[13]

12. Mestci, Z.: Die Unterbindung des Pulmonalishauptastes zur Therapie schwerer Hämoptysen, Zentralbl. Chir. **65**:1294-1295 (June 4) 1938. Armand Ugón, C. V.; de Estable, M. C., and Lockhart, J.: Ligadura de la rama izquierda de la arteria pulmonar por hemoptisis grave. Arch. urug. med. **25**:230-236 (Aug.) 1944.

13. Davis, H. A.: A Method of Surgical Management of the Difficult Patent Ductus Arteriosus: A Preliminary Experimental Study, M. Arts & Sc., to be published.

SUMMARY AND CONCLUSIONS

Temporary occlusion of the left pulmonary artery was carried out in monkeys for varying periods up to seven days. Reestablishment of the blood flow through the pulmonary tissue produced alterations in the lung, consisting of edema of the alveolar walls, passage of fluid, red blood cells, and macrophage cells into the alveoli, and varying degrees of congestive atelectasis. These changes were severest in the lingula of the left lung. Temporary occlusion of the pulmonary artery was well borne for periods up to 48 hours. The pulmonary changes produced were reversible, but beyond this time they were more likely to become irreversible. It is suggested that pulmonary tissue has a considerable resistance to the ischemia produced by occlusion of the pulmonary artery. The practical application of these results to conditions requiring temporary occlusion of the pulmonary artery is discussed.

STENOSING TENOVAGINITIS AT THE WRIST AND FINGERS

Report of 423 Cases in 369 Patients with 354 Operations

PAUL W. LAPIDUS, M.D.
AND
RICHARD FENTON, M.D.
NEW YORK

AT PRESENT, stenosing tenovaginitis is a well-known entity. It occurs most commonly about the hand and wrist in the flexor tendon sheaths of the lesser fingers (trigger finger), in the sheath of the flexor pollicis longus, and in the sheath of the abductor pollicis longus and the extensor pollicis brevis. It has been observed, but more rarely, about the ankle and foot.[1]

The rather frequent stenosing of the common sheath of the abductor pollicis longus and the extensor pollicis brevis remained unrecognized until its classical description by de Quervain in 1895.[2] As pointed out by Finkelstein[3] in 1930, the condition was accorded scant recognition in the American literature and continued to mystify the physicians of this country during the first decades of this century, often being erroneously diagnosed as arthritis, neuritis, or periostitis.

Although the modern orthopedic surgeon has no difficulty in recognizing and treating stenosing tenovaginitis, the general practitioner and even the general surgeon, as will be shown in our series, are still often baffled by these cases and not infrequently fail to diagnose and treat them properly. In addition, this paper seems to be justified, since, to the best of our knowledge, there is no report of as large a series of cases as is presented here.

We wish to report on a total of 369 patients with 423 tendon sheaths involved; 354 operations were performed; 72 patients were personal patients of one of us (P. L.) and have detailed records and adequate follow-up observations. Many of our conclusions are based mainly on these cases. The remaining patients are private and service patients mostly from the Hospital for Joint Diseases.[4] All the service patients were operated on by the residents. Some of them have incomplete records

From the Hospital for Joint Diseases.

This article has been shortened for publication in the ARCHIVES by omission of detailed case reports. These will appear in the authors' reprints.

1. Lapidus, P. W., and Seidenstein, H.: Chronic Non-Specific Tenosynovitis with Effusion About the Ankle: Report of 3 Cases, J. Bone & Joint Surg. **32A**:175-179, 1950.

2. de Quervain, F.: Über eine Form von chronischer Tendovaginitis, Cor.-Bl. schweiz. Aerzte **25**:389, 1895.

3. Finkelstein, H.: Stenosing Tenovaginitis at the Radial Styloid Process, J. Bone & Joint Surg. **12**:509-540, 1930.

4. Members of the Orthopedic Staff of the Hospital for Joint Diseases gave permission for reports of these cases.

and follow-up observations. However, 44 patients in the latter group were recently thoroughly reexamined by one of us (R. F.), and these examinations contributed dependable data for our study.

It is not within the scope of this paper to review the abundant bibliography on the subject.

ANATOMY AND MECHANICS

A tendon is always stretched on a straight line except when it passes over a bony prominence (medial malleolus in the case of the posterior tibial tendon) or when it crosses a joint (flexor tendons of the wrist and fingers). In both these instances a synovial sheath is usually provided at the point of angulation of the tendon in order to decrease the friction. In addition to that, the deep fascia at the tendinous

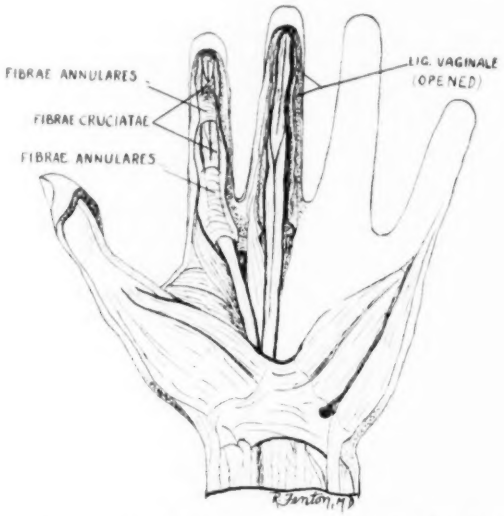


Fig. 1.—Reinforcements of deep fascia by transverse and cruciate fibers at bend of finger joints.

bend becomes reinforced, forming an annular ligament which acts as a pulley or a retinaculum, preventing the tendon from slipping from the bony prominence or from becoming separated from the joint in flexion in a manner similar to a bowstring.

These retinacula are present on both dorsal and palmar aspects of the wrist joint (annular ligament), but only on the palmar aspect of the metacarpophalangeal and interphalangeal joints of the fingers. The fingers, used mostly for grasping, possess a wide range of palmar flexion and practically no dorsiflexion (beyond 180 degrees). Hence, there is no possibility of "bowstringing" of the extensors of the fingers and, therefore, no need for retinacula to prevent separation of the extensor tendons from the dorsal surfaces of the fingers and hand.

Figure 1 illustrates the reinforcements of the deep fascia by transverse and cruciate fibers at the bend of the finger joints. It may also be noted that these reinforcements are present at both interphalangeal joints, but are most strongly developed on the palmar aspect of the metacarpophalangeal joint forming the ligamentum vaginale digiti, and that the flexor tendons become deprived of any real sheath just

proximal to the metacarpal necks. This arrangement, of course, is necessary, since the "bowstringing" of the flexor tendons is more prone to take place at the metacarpophalangeal joints, and there is greater stress, on flexion, at this point compared with the proximal and especially the distal interphalangeal joints, the latter having the least need for a retinaculum.

1. *Flexor Digitorum Longus.*—The flexor tendons of the fingers run loosely in the soft tissue of the palm until they suddenly enter a narrow tunnel of synovial sheath that is formed by the grooved palmar cortex of the metacarpal neck and also a ligamentum vaginale digiti which is almost as tough and unyielding as the bone. Filling this narrow tunnel are two tendons, the flexor digitorum sublimis and flexor digitorum profundus, which pass through each sheath. At the distal part of the sheath the sublimis divides itself into two tendinous slips, letting the tendon of the profundus pass between them.

The human hand is mostly used for grasping, which may be accomplished in various ways. Carrying a heavy pail or using a hammer calls for strong clenching of the hand around the object which is being held. A watch maker, a writer, or a needle worker presses the tip of the flexed index finger, and sometimes also that of the third finger, against the tip of the opposed thumb. This "pinching," so admirably described by Bunnell,[5] requires formation of a firm "O" between the thumb and the index finger. For this, the first metacarpal must be stabilized in abduction at the carpometacarpal joint primarily by strong action of the abductor pollicis longus (Fig. 2).

2. *Flexor Pollicis Longus.*—The anatomy and the mechanics of the sheath of the flexor pollicis longus are somewhat similar to those of the flexor tendons of the lesser fingers, except that the thumb has only one long flexor tendon. This tendon also passes through a narrow, unyielding sheath on the palmar surface of the first metacarpal neck. The two heads of the flexor pollicis brevis ride astride on this sheath, each running over a sesamoid on the radial and ulnar sides of the first metacarpal head to their insertion onto the base of the proximal phalanx. The sheath is the narrowest at the level of the sesamoids.

3. *Abductor Longus and Extensor Brevis Pollicis.*—The anatomical relations of the sheath of the abductor pollicis longus tendon, which it shares with the extensor pollicis brevis at the radial styloid, are much the same as those described above for the flexors of the fingers. Here again, the two (or more, see below) tendons pass through a narrow unyielding tunnel formed by the shallow bony groove over the radial styloid and the strong annular ligament of the wrist. As pointed out by Bunnell,[5] the tendons of the abductor longus and the extensor brevis pollicis are subjected to a rather sharp angulation (up to 105 degrees) at the radial styloid on extreme radial deviation of the hand and abduction of the thumb. Bunnell also noted that this angulation may be greater in women than in men, suggesting an explanation for the preponderance of stenosing tenovaginitis at the radial styloid in females. (In our series there were 140 female patients, or 88%, and 19 male patients, or 12%.)

CAUSATION, PATHOLOGICAL CHANGES, AND SYMPTOMS

The causation of stenosing tenovaginitis in its various locations is grossly the same. It occurs most commonly in a manual worker as a result of continuous use

5. Bunnell, S.: Surgery of the Hand, Philadelphia, J. B. Lippincott Company, 1944.

of the limb in performing certain operations, such as hammering, hand sewing, wringing clothes, and stretching leather. The condition is more prone to develop in a new worker unaccustomed to the job, in an old worker out of training when returning to his task after a period of idleness, or in a worker who is asked to speed up his output to meet a new production quota. Although sometimes acute trauma may produce the lesion, in most cases it is rather of an occupational nature and, therefore, must be considered compensable in the industrial cases.

Constant forceful friction of the tendon against the narrow part of the sheath may produce inflammatory changes, with subsequent scar formation and further narrowing of the sheath. An hourglass constriction may form over the sheath and likewise over the tendon, and the latter often loses its pearly, lustrous appearance and becomes dull and reddish. Granulations and a few drops of serous effusion may be present in the sheath in the acute cases.

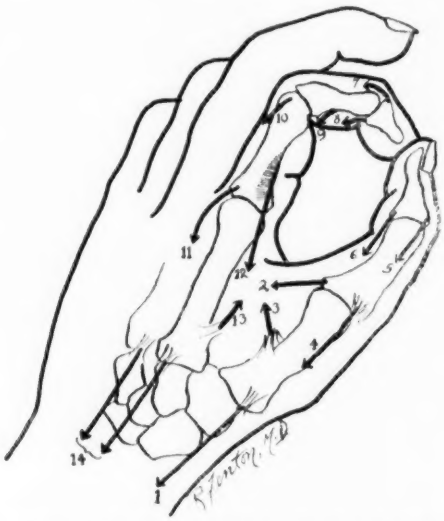


Fig. 2.—Elements involved in formation of "O" by thumb and index fingers, necessary for adequate pinch; (*1*) abductor pollicis longus; (*2*) adductor pollicis; (*3*) cicatricial contracture which, if present, may prevent adequate stabilization of the first metacarpal in abduction; (*4*) extensor pollicis brevis; (*5*) extensor pollicis longus; (*6*) flexor pollicis longus; (*7*) tendon of interosseus; (*8*) flexor digitorum profundus; (*9*) flexor digitorum sublimis; (*10*) long extensor and intrinsics; (*11*) extensor digitorum communis; (*12* and *13*) interosseum and lumbricalis and (*14*) extensor carpi radialis. The thumb is stabilized by its abductor longus (*1*) and extensor bervis (*4*). (Modified from Bunnell.[5])

At the radial styloid in 19 of our 147 explored sheaths, some anomalous situation was recorded. This figure is probably very low, because only a few of the surgeons actually looked for such a situation. These include cases with three or more tendons within the sheath, others with a third tendon in its own sheath beneath the abductor longus and extensor brevis, still others with separate sheaths for abductor and extensor, and, finally, some with absence of one tendon. Bunnell [5] (p. 336) reported that in 12 of his 22 cases of de Quervain's disease the finger contained an aberrant tendon.

All the standard textbooks of anatomy state that the abductor pollicis longus occasionally has an anomalous additional tendon which inserts itself into the greater multangular bone and the fascia of the thenar muscles. Our own anatomical study, based on dissection of 58 wrists (to be published later), showed that in practically all the cadavers we thus far have examined (including the eight wrists of fetuses of 4 to 6 months of gestation) the "aberrant" tendon of the abductor pollicis longus was constantly present; furthermore, sometimes three or more tendons were found in the sheath at the radial styloid, and occasionally two separate sheaths were noted. The extensor pollicis brevis tendon is much thinner than that of the abductor longus and may have a separate sheath.

Bunnell postulated the possibility that these abnormalities predispose to stenosing tenovaginitis, because ". . . the amplitude of motion of the aberrant tendon, having a shorter lever arm, is shorter than that of the tendon of the abductor pollicis longus, so when they are pulled by a common muscle the mechanics are not right."

At first, the patient has difficulty and pain on active flexion of the lesser fingers or thumb, and a snap may be felt and heard when the finger is about two-thirds flexed and extended. A bulbous enlargement may form over the tendon just distal to the neck of the hourglass constriction of the sheath. Forceful active contraction of the flexors of the fingers may pull the bulbous enlargement of the tendon through the constriction, producing a typical "snap." Each lesser digit has two flexors, and they are more powerful than the respective extensors. Therefore, some patients may be able to flex the finger actively with a "snap," but after that the finger may remain locked in flexion and the patient is forced to use the other hand to aid in straightening the finger, as the relatively weak extensors are unable to do so. Occasionally the locking in flexion may remain permanent, as the bulbous enlargement of the tendon, after being pulled proximally to the constriction of the sheath, may become incarcerated in this position. This is most commonly observed in cases of stenosing tenovaginitis of the thumb. Particularly in infants, the main finding is frequently the irreducible flexion deformity of the nail phalanx of the thumb.

Flexion deformity of the lesser fingers usually occurs at the proximal interphalangeal joint, apparently since the sublimis tendon is most involved, although the profundus may be involved, too. Occasionally, after a period of snapping on flexion and extension, the patient may find that suddenly he is unable to flex his finger actively. This evidently is caused by the increase of tendinous enlargement distal to the constriction, making it impossible to pull the tendon through it.

In the lesion at the radial styloid we have never observed "snapping." However, some restriction of active abduction of the thumb has been frequently present.

DIAGNOSIS

1. *Stenosing Tenovaginitis of the Sheath of the Flexor Digitorum.*—When a patient, usually a manual worker, complains of pain on motion at the base of the finger with occasional snapping and locking, the diagnosis is self-evident. Not infrequently snapping and locking may not be present, but localized midline tenderness only along the palmar aspect of the metacarpal neck without periarticular tenderness is practically a constant finding, except in chronic cases of months' or years' duration. Loss of terminal active and passive extension at the proximal interphalangeal joint, with local pain on attempting extension, is also frequently found.

Fixed flexion deformity at the proximal interphalangeal joint, or loss of active flexion at this joint with unrestricted passive flexion and localized tenderness only along the sheath, also suggests the above diagnosis.

2. Stenosing Tenovaginitis of the Sheath of the Flexor Pollicis Longus.—Only in this location was the lesion observed in several infants. These presented either a fixed or a "snapping" flexion deformity of the nail phalanx, together with local tenderness only along the palmar aspect of the first metacarpal neck. Snapping is less frequently observed than in the same condition in adults. Discovery of this lesion shortly after birth and the occasional bilateral occurrence have led to the considering of this condition as "congenital." However, there is no adequate proof that it is truly present at birth. Its appearance in infants still requires satisfactory explanation. Thumb-sucking has been blamed, but it is difficult to prove that this causes the lesion.

3. Stenosing Tenovaginitis of the Sheath of the Abductor Longus and Extensor Pollicis Brevis.—The patient frequently presents considerable localized tenderness along the sheath over the radial styloid, with often a visible or palpable enlargement. There is localized pain on passive ulnar deviation of the hand, especially when the thumb is held flexed and within the fist. The latter sign is pathognomonic. There is also pain on active abduction of the thumb against resistance. The patient often has difficulty in lifting objects and sometimes drops them when attempting to pick them up.

DIFFERENTIAL DIAGNOSIS

If one is constantly conscious of the possibility of stenosing tenovaginitis, there is little chance of overlooking it, except perhaps in an occasional atypical case. A traumatic lesion or osteoarthritis of the finger joints is easily differentiated by the absence of locking and snapping. There is in the latter conditions generalized periarticular tenderness instead of the typical pain and tenderness localized entirely along the sheath. There are also roentgenographic changes that are not found in stenosing tenovaginitis.

It must be kept in mind, however, that stenosing tenovaginitis may affect a finger with old osteoarthritis (see Case 3).

Inflammatory lesions of the tendon sheaths, both acute and specific (tuberculosis), acute trauma, or bone neoplasm may be mentioned under differential diagnosis for theoretical interest only, as they have never been of any practical importance in our experience. Nevertheless, although the diagnosis seems to us quite simple, we feel that thorough examination including roentgenograms should be recommended as a routine.

ANALYSIS OF STATISTICS

Site and Frequency.—For this paper we have reviewed records of 369 patients who had involvement of 423 tendon sheaths. Table 1 shows the tendon sheaths involved, with the frequency of each.

Sex.—Females were involved much more frequently than males, except in cases in which the lesser finger sheaths were the site of the stenosing tenovaginitis. In the latter cases there were equal numbers of males and females. Of a total of 369 patients there were 92 males (25%) and 277 females (75%).

Age.—The average age of patients in this series was 46 years. The greatest number of patients were between 30 and 60 years of age.

Right or Left Involvement.—Among cases of involvement of the lesser fingers, right-sided involvement prevailed 2 to 1; in the other cases the proportion was approximately 1 to 1.

TABLE 1.—*Tendon Sheaths Involved*

Tendon Sheath	Number of Sheaths	% of Total
Sheath of the abductor pollicis longus and extensor pollicis brevis	165	39.0
Sheath of flexor pollicis longus	135	31.9
Flexor sheath of 2d finger	4	1.0
Flexor sheath of 3d finger	44	10.4
Flexor sheath of 4th finger	46	10.9
Flexor sheath of 5th finger	16	3.8
Sheath of extensor pollicis longus*	6	1.4
Sheath of extensor carpi radialis longus*	2	0.5
Sheath of extensor carpi radialis brevis*	2	0.5
Sheath of flexor carpi radialis*	1	0.2
Sheath of extensor to 2d finger*	1	0.2
Sheath of extensor to 5th finger*	1	0.2
Total	423	100.0

* None of these cases, except Case 17, was seen by us; data were obtained from operative records on the charts, and in some of the cases diagnosis may be questionable.

TABLE 2.—*Age Distribution*

Decade	Age, Yr.	Number of Sheaths	% of Total
1st*	0-10	15	3.5
2d†	11-20	3	0.1
3d	21-30	34	8.0
4th	31-40	62	14.7
5th	41-50	125	29.6
6th	51-60	141	33.3
7th	61-70	40	9.5
8th	71-80	3	0.7
Totals		423	100.0

* Stenosis of the flexor pollicis longus sheath was the only lesion that occurred in this group.
† All these patients were over 17 years of age.

TABLE 3.—*Type of Involvement*

Side	No.	Sheaths, %	No. Radial	Styloid, %	No. Lesser	Fingers, %	No. Flexor	Pollicis Longus, %
Right	234	55.3	81	49	73	66.4	75	55.6
Left	189	44.7	84	51	37	33.6	60	44.4
Total	423	100	165	100	110	100	135	100

Occupation.—The greatest single group were housewives (149). This is understandable in that the housewife does many tasks that predispose to stenosing tenovaginitis, for example, wringing clothes, sewing, cutting, and carrying heavy objects. To this group can be added the domestics (13), who do similar tasks, bringing the total in this group to 162 patients. The second largest occupational classification

was the sewing-machine operators (34), while the third largest group was the needle workers (32). In many of the other occupations listed, it is easy to see how an abnormal strain is put on some of the various tendon groups.

In a total of 334 adult patients there were 149 housewives; 34 machine operators; 32 needle workers; 27 clerks; 13 domestics; 7 physicians; 7 managers; 7 furriers; 5 secretaries; 4 waiters and waitresses; 4 pressers; 4 bookkeepers; 3 leather workers; 3 beauticians; 3 metal workers; 3 nurses; 3 packers; 3 laundresses; 2 peddlers; 2 laborers; 2 barbers; 1 dentist; 1 elevator operator; 1 teacher; 1 painter; 1 porter; 1 social worker; 1 broker; 1 designer; 1 cigar roller; 1 photographer; 1 artist; 1 lawyer; 1 telephone operator; 1 candy maker; 1 advertising man; 1 driver; 1 dish washer. Eleven patients were children.

Trauma.—Although many of the histories were inadequate, definite trauma was mentioned in 32 cases. In three of these there were metacarpal fractures within six weeks of the onset of symptoms of stenosing tenovaginitis of the flexor sheaths of the lesser fingers.

Duration of Symptoms.—In 109 patients the duration of symptoms was recorded. This varied from five days to 11 years. The duration in most patients was less than six months. Duration of symptoms was 1 month or less in 31 cases;

TABLE 4.—*Incidence in Flexor Sheaths of Lesser Fingers*

	Patients			Sheaths	
Sex	No.	%	Side	No.	%
Male	42	48	Right	73	66.4
Female	45	52	Left	37	33.6
Totals	87	100	Totals	110	100

2 months in 17; 3 months in 13; 4 months in 9; 5 months in 10; 6 months in 5; 7 months in 3; 8 months in 6; 9 months in 1; 1 year in 8; 2 years in 3, and 3, 10, and 11 years in 1 case each.

Operations.—Three hundred sixty-seven sheaths were operated upon; 56 were not. Of the latter group recovery was spontaneous in 14 cases. Ninety-five of the cases with operation were followed adequately and will be reported under each anatomical location.

Frequent findings at the time of operation were thickening of the sheath, with constriction of the tendon and a distal or more frequently, proximal bulge in the tendon. A ganglion within the sheath was recorded in 10 cases. In the more acute cases, a small amount of fluid was within the sheath and some granulations were present on the tendons and in the sheaths. In 96 operations a pathological examination was performed, and all lesions were reported as typical, chronic, nonspecific, inflammatory ones. In 22 of these it was also noted that there were fibrocartilaginous changes within the sheath.

Analysis of Findings in Stenosing Tenovaginitis of Flexor Sheaths of Lesser Fingers.—In all, 110 flexor sheaths of the lesser fingers were involved in 87 patients. None of the patients were children. Approximately half the cases were in men and half in women. The right hand was involved twice as frequently as the left.

In 18 patients two or more sheaths were involved. Of these, 10 had bilateral stenosis. The fingers most frequently affected were the fourth and the third. In eight patients the third and fourth fingers of the same hand were involved. Of the total of 110 lesions of the flexor sheaths of the lesser fingers, stenosis was present in 4 sheaths of the second finger (3.7%); in 44 sheaths of the third finger (40.0%); in 46 sheaths of the fourth finger (41.8%), and in 16 sheaths of the fifth finger (14.5%).

Results: Eighty-seven lesser fingers were operated upon. Of these, 34 had adequate follow-up observation for more than six months. An "excellent" result was one in which there was complete function and no symptoms. A result was considered "good" if there was a slightly tender scar or a slight limitation of extension (under 10 degrees) but no snapping or locking and no pain on motion. In 34 lesser fingers with postoperative follow-up observation, the result was excellent in 31 fingers, or 91.2% (two fingers listed as showing excellent results required a second operation because of persistence of snapping), and good in 3 fingers, or 8.8%. Twenty-three fingers were not operated upon. Of these five were known to have had spontaneous recovery following either immobilization or no treatment at all. However, there were fingers with persistence of symptoms as long as 11 years.

TABLE 5.—*Incidence in Sheath of Flexor Pollicis Longus*

	Right	Left	Total		Male	Female	Total
Adults.....	75 (55.6%)	60 (44.4%)	135	Adults.....	26 (21.7%)	94 (78.3%)	120
Children.....			11	Children.....			11

Analysis of Findings in Stenosing Tenovaginitis of Sheath of Flexor Pollicis Longus.—There were 135 sheaths stenosed in 120 patients. Of these patients, 11 were children (under 10 years of age) and 109 were adults. The right thumb was involved slightly oftener. There were four times as many females as males in our total series with involvement of the thumb. In 15 patients there was bilateral stenosis.

Results: One hundred twenty operations were performed. Fifteen patients were not operated upon. Twenty-nine cases with operation were followed adequately. A result was considered "excellent" if there was complete function and no symptoms. A result was listed as "good" if there was either slight numbness of the pad of the thumb or slight tenderness over the scar. A result of both slight numbness and tenderness or one of severer sensory loss was considered only "fair." Results in patients with a combination of the above symptoms or with no relief of the original snapping or locking were labeled as "poor." All the "poor" results in our entire series were limited to service cases.

On follow-up observation in 29 operations on the thumb the result was considered as excellent in 23 thumbs (79%). Two thumbs listed as showing an "excellent" result required a second operation because of persistence of snapping. Results were good in 2 (7%); fair in 2 (7%), and poor in 2 (7%). The postoperative symptoms were tenderness in three patients; pain in two; loss of sensation in pad in four; stiffness in one; inability to resume work in one; persistence of snapping in one. (Several symptoms may have appeared in one patient.)

Analysis of "Poor" Results: C. C., a 58-year-old white male, barber, presented a classic picture of stenosing tenosynovitis of the flexor pollicis longus. On Oct. 12, 1949, the sheath was incised. The patient was seen by one of us (R. F.) in April, 1950. At that time he had complete numbness over the pad of the thumb. He suffered pain constantly on use of the thumb and complained of stiffness. He had been unable to return to his work (barbering).

M. F., a girl, had bilateral stenosing tenosynovitis of the flexor pollicis longus, noted at about 3 months of age. On June 29, 1939, when the patient was 2 years old, the right thumb was operated on, with an excellent result. On Jan. 26, 1944, the left thumb was operated on. When she was seen in April, 1950, there was snapping of the left thumb. The mother stated that this had persisted continuously since the last operation.[6]

Of the 15 patients not operated upon, 6 were known to have recovered spontaneously.

Analysis of Findings in Stenosing Tenovaginitis at Radial Styloid Process.—One hundred sixty-five sheaths were stenosed in 159 patients, making 6 bilateral cases. Right and left wrists were equally affected. Females outnumbered males 7 to 1. None of the patients were children.

One hundred forty-seven sheaths were operated on in 143 patients. Thirty-two cases were thoroughly followed. A result was again considered "excellent" only if function was 100% and there were no symptoms. A case with a "good" result was

TABLE 6.—*Incidence at Radial Styloid Process*

	Patients			Sheaths	
Sex	No.	%	Side	No.	%
Males	19	12	Right	81	49
Females	140	88	Left	84	51
Totals	159	100	Totals	165	100

one in which there was slight tenderness, a painless, adherent scar, or slight paresthesia. Cases listed as having "fair" results are those with any two of the above symptoms or those with one of the following: tenderness, keloid formation, slight pain, or a tender, adherent scar. Cases with "poor" results are those in which there was a positive result on the ulnar deviation test, severe pain, or severe weakness. In the 32 cases followed up, the postoperative result was considered excellent[7] in 22 sheaths (68.8%); good in 4 (12.5%); fair in 3 (9.4%), and poor in 3 (9.4%). Of the 32 patients followed up, 10 had one or more of the following symptoms: pain in 5; tenderness in 4; paresthesia in 2; adherent scar in 2; weakness in 2; positive result on ulnar deviation test in 2, and keloid in 1.

Analysis of "Poor" Results: L. W., a 42-year-old Negro woman who was a sewing-machine operator, had a typical history and physical findings of stenosing tenovaginitis of the extensors

6. Since this paper was first written M. F. was reoperated upon with complete relief.

7. An excellent result was achieved in one case only after a second operation. After the first operation, at which time a moderately thickened sheath was incised, the patient had no relief of pain. Three months later he was reoperated on and it was found that the original sheath did not constrict the tendon. However, on retracting the very thick abductor tendon, an anomalous sheath and tendon were found lying deep below the normal sheath. When this sheath was excised, the tendons moved smoothly. The anomalous tendon acted as an extensor of the thumb. After this, the patient had complete relief. (Fenton, R.: Stenosing Tendovaginitis at the Radical Styloid Involving an Accessory Tendon Sheath: Report of 3 Cases, Bull. Hosp. Joint Dis. **11**:90-95, 1950.)

of the left thumb. On Dec. 8, 1948, the thickened sheath was excised through a longitudinal incision. The pathologist's report was typical stenosing tenovaginitis.

Follow-up observation in January, 1950, revealed that there was no relief of symptoms. She was unable to return to work. There was marked weakness (50% of normal). She had a tender keloid and mild Sudeck's atrophy of the lower end of the radius and carpal bones. She complained of radiating pain.

On March 29, 1950, she was reoperated on and a subcutaneous nodule was excised. No constriction in the sheath was seen.

Follow-up examination in April, 1950, revealed no essential change since January. The reaction to the ulnar deviation test was strongly positive.

S. W., a 62-year-old Negro housewife, had a classic picture of involvement of the extensors of the left thumb. On Oct. 4, 1949, the sheath was released through a longitudinal skin incision.

TABLE 7.—*Types and Incidence of Anomalies Seen in Tenovaginitis at Radial Styloid*

Anomaly	Number of Times Seen
1. Accessory tendons within one sheath	
a. Total of 3 tendons	7
b. Total of 4 tendons	1
c. Total of 5 tendons	1
Total	9
2. Anomalous tendon with its own sheath beneath the sheath of the abductor longus and extensor brevis	3
3. Separate sheaths for abductor longus and extensor brevis	4
4. Only one tendon found	3
Total	19

TABLE 8.—*Further Involvements Discovered on Follow-Up Examination*

Patient	Original Involvement	Additional Involvement
1	Flexor pollicis longus, rt.	Flexor 4th finger, lt.
2	Flexor pollicis longus, rt.	Flexor thumb, lt. Flexor 2d finger, rt. Flexor 4th finger, rt.
3	Flexor pollicis longus, lt. Flexor 3d finger, rt.	Flexor 3d finger, lt.
4	Flexor 2d finger, rt.	Flexor thumb, lt.
5	Radial styloid, rt.	Flexor 3d finger, rt. Flexor 4th finger, lt.

Follow-up examination in April, 1950, revealed moderate pain and a positive result on the ulnar deviation test.

E. E., a female Negro domestic, 47 years of age, presented a typical involvement of the extensors of the left thumb. On Feb. 2, 1949, a release was performed through a longitudinal skin incision.

Follow-up examination in April, 1950, showed that the patient had marked weakness of the thumb with pain and a positive result on the ulnar deviation test.

We wish to emphasize that the two patients with adherent scars and the one with keloid formation, all had a longitudinal skin incision. In none of the patients with transverse incision was there any difficulty with the scar.

Of the 18 patients not operated on, 3 had spontaneous recovery.

Anomalies: In 19 cases some anomalous situation was recorded. (For discussion, see section on causation, pathological aspects, and symptoms.)

Further Involvement Discovered at Follow-Up: Of the 44 service cases reviewed on follow-up examination, five of the patients had acquired additional stenosis since they were discharged.

TREATMENT

Immobilization for two or three weeks with fair chance for recovery may be tried in early cases with symptoms of not more than four or six weeks' duration. Cases of longer duration are less prone to respond to conservative treatment.

Although we have definite cases of gradual spontaneous recovery, often six or more months after the onset of the condition, we also have seen patients with persistence of symptoms for as many as 11 years.

The operative procedure, in competent hands, is a comparatively simple one and brings prompt relief. Therefore, we feel that the operative release is indicated in cases of more than one month's duration, particularly in wage earners whose prompt return to work is essential.

OPERATION

On practically all of our patients, except infants, operation was performed with the field under local block anesthesia, using 2% procaine solution without epinephrine. Sometimes as little as 5 cc. of the solution was enough to produce excellent analgesia.

The field is practically always bloodless; in our own cases we have never used a tourniquet.

The skin incision must be made along the skin creases; at the radial styloid it should always be transverse over the skin, the subcutaneous structures being divided longitudinally and mostly by blunt dissection. Superficial branches of radial nerve (at the radial styloid) and palmar digital nerves and the blood vessels should be carefully protected during the dissection and also on retraction. In all our cases involving the flexors of the lesser fingers and thumb, except the extremely unusual Case 19, the constriction was always at the level of the metacarpal neck.

A single L-shaped incision following the palmar creases at the metacarpal heads, in our experience, gives adequate exposure, and any additional incisions distally to it over the fingers, used by a few surgeons in our series, seem to us to be superfluous.

On the thumb, a transverse, or better yet, an L-shaped skin incision following the basal palmar crease should be used, the longitudinal leg of the L being made along the ulnar side of the thumb. We prefer the L-shaped incision, since it gives more extensive exposure and eliminates the need for excessive retraction and damage to the lateral palmar cutaneous nerve. This temporary complication was noted in a few of our cases; in one patient it was permanent and more disabling than the original lesion.

In the majority of our cases we used the midline splitting of the sheath and found no difference in our final results when the sheath was incised at its side. Complete division of the entire sheath, which may be 1 in. (2.5 cm.) or more long, is essential. We usually ask the patient to move the finger to make sure that the constriction has been completely eliminated and free gliding of the tendon reestablished; that is also one of the reasons in favor of local anesthesia.

Only the skin should be sutured. In a couple of cases in our series (with operation by other surgeons) in which the tendon sheath or the subcutaneous tissues were sutured, recurrence developed necessitating a second operation.

A very small dressing is applied, allowing immediate motion. This dressing is changed to even a smaller one the next day, and active motions are strongly advocated. Many of the housewives in our series performed some of their work on the second postoperative day.

During recent years penicillin has been administered preoperatively and for a day or two after the operation. There was only one case of mild superficial infection in a patient with stenosing tenovaginitis of the fourth finger. This was a ward service patient, and infection was presumably due to rough handling of the wound by an inexperienced resident. It cleared promptly with penicillin therapy, and the final result was good.

AFTER-CARE

Stitches were removed at the end of the seventh or eighth day, and most of our patients resumed their work two or three weeks after the operation. Compensation cases, especially in heavy laborers, required an extra week or two. With a very few exceptions, no physical therapy was necessary for postoperative rehabilitation.

RESULTS

Practically all our personal patients had good or excellent functional results after the operation. In a few neglected cases of long duration there was postoperative persistence of a slight flexion contracture (mostly at the proximal interphalangeal joint), but even that frequently disappeared later.

SUMMARY

Attention is called to frequently occurring stenosing tenovaginitis at the radial styloid and at the flexor sheath of the fingers, which are often misdiagnosed. A series of 369 patients with 423 sheaths involved and 354 operations performed, is analyzed. In a great majority the condition is an occupational one and, therefore, compensable in the industrial workers.

Although spontaneous recovery may occur, operative release is preferable, particularly when symptoms are present more than one month. Operative technique is described; the importance of skin incisions along the skin creases (transverse at the radial styloid), suturing of the skin only, and immediate postoperative mobilization, is emphasized.

FRACTURES OF THE ANKLE

IV. Clinical Use of Genetic Roentgen Diagnosis and Genetic Reduction

N. LAUGE-HANSEN, M.D.
RANDERS, DENMARK

TWO EARLIER papers[1] described how four types of ankle fractures in different (two to four) stages were produced, how their mechanism was established by experimental surgery, and how they were pathologically determined by dissection and genetically classified by experimental roentgenography.

Study has been made on clinical material to verify the fact that the four types experimentally produced and classified correspond to the clinical fractures of the ankle and that the genetic roentgen diagnosis and the genetic reduction technique found by way of experiments can be used in the treatment of fresh ankle fractures.

GENETIC ROENTGEN DIAGNOSIS

Fractures of bones of the leg were included in the clinical material in order to insure that all fractures properly belonging to the ankle-fracture group are dealt with, because in some cases of ankle fractures the fibular fracture is found so far proximal to the ankle joint that the clinical department may not have included it under the heading of ankle fractures but grouped it under fractures of bones of the leg, which of course, holds good, especially when the lesion in the ankle region does not produce conspicuous symptoms.

Another reason for the inclusion of fractures of bones of the leg is to see if by the study of the material consisting of both fractures of the ankle and fractures of bones of the leg it is possible to find evidence suggesting that a certain form of tibial fracture in children is analogous to a certain form of ankle fracture in adults.

Case records and roentgenograms have been reviewed for all patients treated or examined roentgenologically for fractures of the ankle or fractures of bones of the leg.

All fractures in which at least one of the fracture lines or a ligamentous lesion involves the ankle joint are classified under ankle fractures. According to this definition all ankle fractures are intra-articular. The material comprises 425 fractures in 425 patients, 228 of whom were adults with ankle fractures.

On the basis of the roentgenograms the 228 ankle fractures in adults were diagnosed and classified into four types according to the manner of production (genesis) in conformity with the characteristic roentgenographic findings of the four types

From the Central Hospital.

1. Lauge-Hansen, N.: Fractures of the Ankle: Analytic Historic Survey as the Basis of New Experimental Roentgenologic and Clinical Investigations, Arch. Surg. **56**:259 (March) 1948; II. Combined Experimental-Surgical and Experimental-Roentgenologic Investigations, ibid. **60**:957 (May) 1950.

of fractures which were experimentally found and which occur pathoanatomically in constant and characteristic stages.

The four types of ankle fractures are described by a dual designation which denotes the two main factors of the individual type of fracture, viz., the position of the foot in the moment of fracturing and the forced movement of the foot producing the fracture.

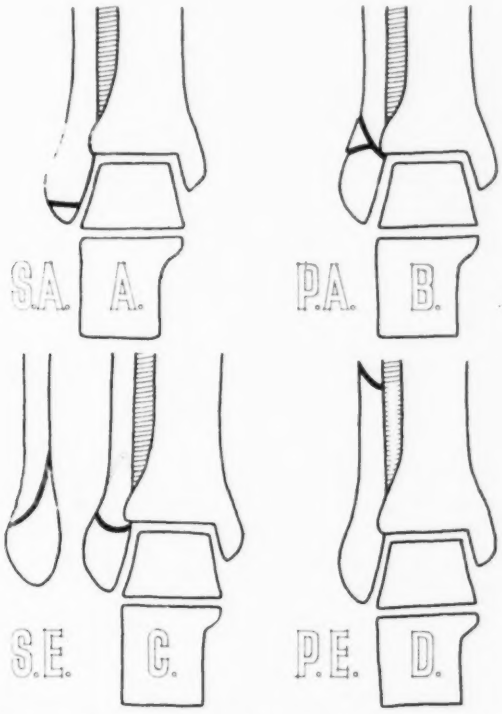


Fig. 1.—Diagrams showing the characteristic localization and form of the fibular fracture decisive for each of the four types of fracture of the ankle (see Figures 2 to 9). *S. A.*, supination-adduction fracture; *S. E.*, supination-eversion fracture; *P. A.*, pronation-abduction fracture; *P. E.*, pronation-eversion fracture. (From Thomasen, E.: Fractures of the Ankle: Genetic Diagnosis and Reduction by the Method of Niels Lauge-Hansen; A Critical Review, Nord. Med. **25**:689, 1945.)

The plan according to which the ankle fractures are produced and all the clinical ankle fractures can be classified is as follows:

Maximal supination of the foot

+ forced adduction = Supination-adduction fracture (Stages 1 and 2)

+ forced eversion = Supination-eversion fracture (Stages 1 to 4)

+ forced inversion = Supination-inversion fracture (ligamentous lesions on the lateral side of the foot)

Maximal pronation of the foot

+ forced abduction = Pronation-abduction fracture (Stages 1 to 3)

+ forced eversion = Pronation-eversion fracture (Stages 1 to 4)

+ forced inversion = Pronation-inversion fracture (fracture of the tibia and fibula)

The four types of ankle fractures are characterized by the localization and form of the fibular fracture (Fig. 1), and the stages in each individual type are determined according to the combination of the fibular fracture with one or more additional fractures involving other parts of the ankle region. Thus, an exact genetic roentgen diagnosis [2] of all ankle fractures is possible, and by determining the type and stage the pathological anatomy is given, also with regard to which ligamentous ruptures may be present in the different types of ankle fractures.

With only three exceptions it was possible to classify the 228 cases within the four groups of ankle fractures. A closer examination in two instances revealed that the fractures were caused by direct trauma. The third case was that of a special fracture (fracture in the medial malleolus and large fragment torn from the ventral lip of the tibia) about which a later paper will be presented.

In the following tabulation the 228 ankle fractures are classified according to the genesis as judged from the roentgenograms:

	M	F	Total
Supination-adduction fracture			
Stage 1	11	6	17
Stage 2	13	6	19
	24	12	36 = 16%
Supination-eversion fracture			
Stage 1	1	6	7
Stage 2	31	26	57
Stage 3	26	12	38
Stage 4	21	40	61
	79	84	163 = 71%
Pronation-abduction fracture			
Stage 1	3	2	5
Stage 2	4	1	5
Stage 3	1	0	1
	8	3	11 = 5%
Pronation-eversion fracture			
Stage 2	2	1	3
Stage 3	2	0	2
Stage 4	5	5	10
	9	6	15 = 7%
Fractures by direct trauma	1	1	2
(Pronation-dorsiflexion fracture	0	1	1)
	1	2	3 = 1%
	121	107	228

In the total material (lower leg and ankle), fracture was found 260 times in men and 165 times in women, the ratio being 1.6:1.

Of 228 ankle fractures, 121 were found in men and 107 in women, the ratio being 1.1 : 1, and in one of the groups fractures were even more frequent in women than in men (see below).

The frequency of fractures in men and women was as follows:

For supination-eversion fractures	79	84	0.9:1
For supination-adduction fractures + pronation-abduction fractures + pronation-eversion fractures	41	22	1.8:1

As it is especially in women from the age of 20 and upward that the great number of supination-eversion fractures is found, and as the fractures of the supination-

2. Lauge-Hansen, N.: Roentgen Examination of the Lesions in the Ankle Region (Historical-Experimental-Clinical): Genetic X-Ray Diagnosis of the Ankle Fractures, Am. J. Roentgenol., to be published.

eversion group occur especially after a false step, stumbling, or slipping in walking or running, i. e., in circumstances in which it must be presumed that the accommodating movability of the foot in its function as an organ of weight-bearing and progression is heavily taxed, it is only natural to assume that this exceptional position of women in the supination-eversion group must be due to special, perhaps acquired, conditions of the foot or ankle joint and to investigate whether the movability of the foot and the ankle joint and the position of the foot in women over 20 should present conditions deviating from the normal.

Investigations showed that in women aged 20 to 40 years changes in the position of the foot and in the movability of the foot and ankle joint have occurred, with the result that the function deviates considerably from the normal. The dorsiflexion was found to be considerably reduced. The reduction of this movement was very pronounced in women from 30 to 40 years of age, and considerable in women from 20 to 25 years of age. The plantar flexion was increased, particularly in women between 20 to 25 years, so that the total value of the movement in the ankle joint was almost as much as that in the normal foot. With advancing age the increased plantar flexion was gradually lost. The supination was considerably reduced in the women between 25 and 40 years of age whom I examined.

Owing to the reduced capability of supination and dorsiflexion of the foot in women who for a number of years have worn ordinary high-heeled shoes, the physiological limit of these movements will be reached more quickly than in men, i. e., the female foot is less accommodating.

Women's use of high-heeled shoes for a number of years thus gives rise to a development by which the pronation of the great-toe system and the capability of the foot as an organ of support and weight-bearing are increased. This advantage is achieved partly at the expense of the function of the foot as an organ of progression, as its movability is reduced and its form changed, so that there is a greater risk of exceeding the limits of physiological accommodating movements of the foot, which in turn explains the comparatively greater frequency of supination-eversion fractures in women.

On the other hand, it seems reasonable to take these facts (that the frequency of supination-eversion fractures in women is twice that of other forms of ankle fractures and that the avoidance of these fractures requires a high degree of supination and dorsiflexion of the foot) as a corroboration of the mechanism of the supination-eversion fracture as ascertained in my experimental surgical investigations.

In the clinical material it was ascertained that the dislocation of the fragments and the subluxation of the talus were never completely overcome by the reduction performed and that the reduction in most cases had been very unsatisfactory indeed. Secondary dislocation was frequently found to be present.

GENETIC REDUCTION

It was possible to make a genetic roentgen diagnosis of the 228 ankle fractures, which proves that the genesis of these fractures was really established by the experimental-surgical investigations. In order to substantiate further the correctness of this fact, I tried to perform the genetic reduction of fresh ankle fractures in accordance with the principles laid down for each individual type by way of experiment.

In the first instance (1941) genetic reduction was performed on 86 fresh ankle fractures and later on several hundred more fractures of the ankle when the genetic reduction was established as a routine method in more Danish hospitals. The reduction has to be performed immediately on the admission of the patient, when the genetic diagnosis had been made by roentgen examination.

In the first cases local anesthesia with injection of 2% procaine solution into the hematoma around the ankle joint was used. This form of anesthesia was gradually given up, as benzine and iodine disinfection of the skin over the generally considerable swelling and hematoma around the fracture caused antiphlogistic bulla formation. Now we use either general or lumbar anesthesia, which gives the complete muscular relaxation required for reduction.

The patient can be placed on a low table or in a bed. The reduction is carried out while the lower extremity is flexed 90 degrees in the hip and knee joints and held thus by an assistant, who with both hands grasps the distal part of the femur at the popies (and holds the extremity so that the patella is turned exactly ventrally) while the operator grasps the foot.

After the reduction (which will be described for each type later on) the fracture is immobilized by a tight-fitting circular plaster cast over a dorsal splint on the lower leg and the sole of the foot. A rubber block is incorporated under the heel, so that it can be used as a "walking" cast.

The reduction is performed without the aid of any instruments.

In the following material the genesis, pathological anatomy, genetic roentgen diagnosis, dislocation, and genetic reduction (and maintenance of reduction) will be explained for each of the four types of ankle fractures.

SUPINATION-ADDUCTION FRACTURE, STAGES 1 AND 2

Genesis.—The genesis of the supination-adduction fracture is forced adduction (hind part of the foot) of a maximally supinated foot.

Pathological Anatomy.—The pathological anatomy is as follows: Stage 1 consists of a transverse fracture of the lateral malleolus in varying height (as an exception just proximal to it) or detachment of the ligaments which are attached to the tip of the lateral malleolus (ligamentum calcaneofibulare and ligamentum talofibulare posterius) with small granular fragments from the tip of the lateral malleolus and/or the lateral surface of the talus. Stage 2 is a combination of Stage 1 and fracture of the medial malleolus.

Genetic Roentgen Diagnosis.—The genetic roentgen diagnosis is illustrated in Figures 2 and 3.

Dislocation.—The malleolar fragments and talus are dislocated medially and turned into the varus position (the talus is sometimes in varus position also in Stage 1).

Genetic Reduction.—Genetic reduction is carried out as follows: The hind part of the right foot is grasped with the right hand at the heel (from the plantar side). The foot is moved ventrally and laterally, abducted and dorsiflexed to the right ankle. With this maneuver the fore part of the foot is pronated somewhat, so that the tip of the foot becomes a little everted in relation to the continuation of the medial axis through the crus, i. e., the normal position of the pronated foot in dorsiflexion.

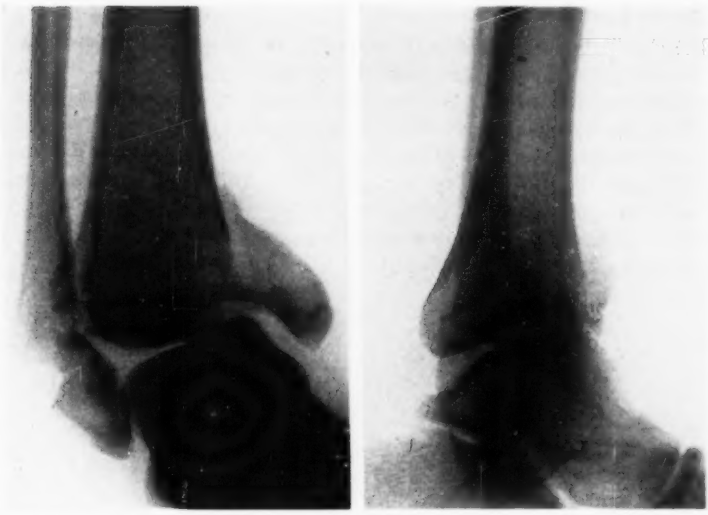


Fig. 2.—Supination-adduction fracture, Stage 2. Notice (1) the characteristic localization and form of the fibular fracture decisive for this type of fracture (first lesion); (2) fracture of the medial malleolus (second lesion), and (3) the direction of dislocation of the malleolar fragments and the talus (see text).

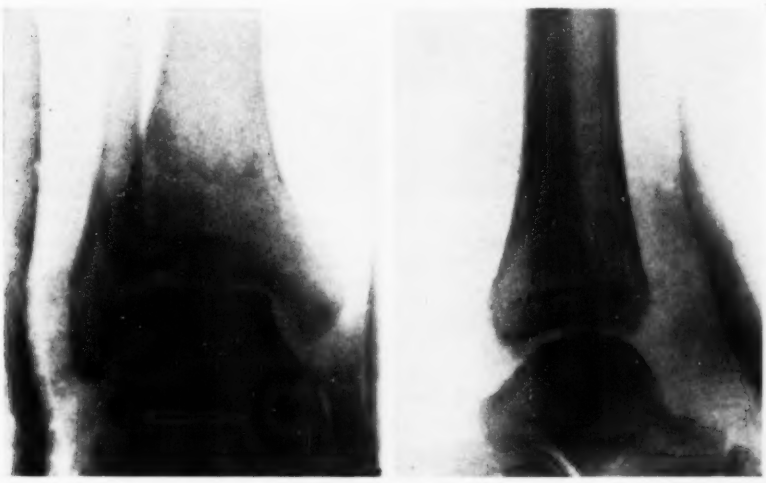


Fig. 3.—Same fracture as in Figure 2 after genetic reduction and application of "walking" plaster cast.

SUPINATION-EVERSION FRACTURE, STAGES 1 TO 4

Genesis.—The genesis of the supination-eversion fracture is forced eversion of a maximally supinated foot.

Pathological Anatomy.—Stage 1 is detachment (with small shell-shaped fragment) of the ligamentum malleoli lateralis anterius (from the lateral malleolus or from the tuberculum anterius tibiae, or both). Stage 2 is Stage 1 plus an oblique spiral fracture of the supramalleolar part of the fibula. Stage 3 is Stage 2 plus avulsion of a small, medium-sized, or large fragment from the dorsal lip of the tibia (to which ligamentum malleoli lateralis posterius and ligamentum malleoli lateralis posterius distale are attached). Stage 4 is Stage 3 plus a fracture of the medial malleolus or detachment of the ligamentum deltoideum.

Genetic Roentgen Diagnosis (Figs. 4 and 5).—In the supination-eversion fractures small bony avulsions corresponding to a detachment of the ligamentum mal-

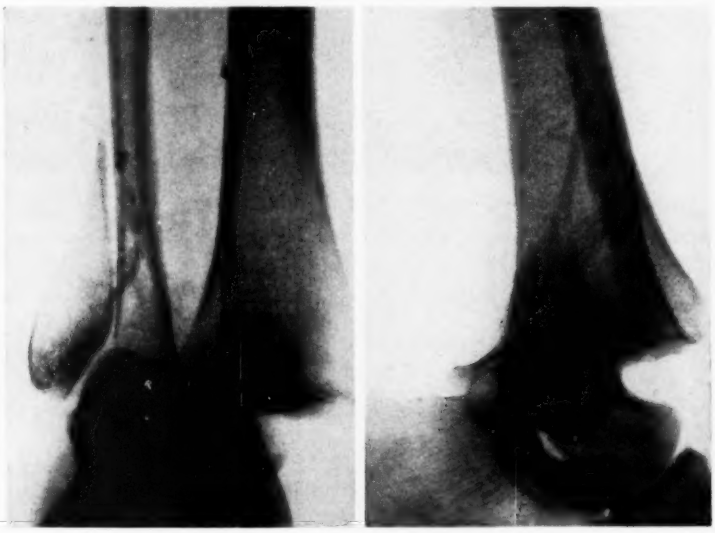


Fig. 4.—Supination-eversion fracture, Stage 4. Notice (1) the characteristic localization and form of the fibular fracture decisive for this type of fracture, more evident in the lateral roentgenogram (second lesion; the first lesion is detachment of the ligamentum malleoli anterius, not visible in this roentgenogram); (2) the fracture of the posterior lip of the tibia (third lesion); (3) the fracture of the medial malleolus (fourth lesion), and (4) the direction of the dislocation of the three fragments and the talus (see text).

leoli lateralis anterius—as shown in Stage 1 in the experimental-surgical investigations—were found, as an isolated phenomenon in 7 cases, in Stage 2 in 42 of 57 cases, in Stage 3 in 32 of 38 cases, and in Stage 4 in 52 of 61 cases.

The small anterolateral tibial fragment was thus found roentgenologically in 133 (82%) of the 163 supination-eversion fractures, notwithstanding the fact that by the roentgen examination nothing particular had been done to establish its existence, a fact which has never before been demonstrated in clinical material and which shows that in cases of oblique spiral fracture of the supramalleolar part of the fibula there is always detachment of the ligamentum malleoli lateralis anterius and that

this oblique spiral fibular fracture is the second lesion of a supination-eversion fracture (as found experimentally).

In a certain percentage of the supination-eversion fractures an avulsion from the dorsal lip of the tibia was found in association with oblique spiral fracture of the supramalleolar part of the fibula. In another percentage an avulsion from the dorsal lip of the tibia was found in association with both oblique spiral fracture of the supramalleolar part of the fibula and fracture of the medial malleolus, or detachment of the ligamentum deltoideum. In cases in which the oblique fracture of the supramalleolar part of the fibula was found in association with fracture of the medial malleolus or detachment of the ligamentum deltoideum fracture of the dorsal lip of the tibia could always be demonstrated. From this it appears that the fracture of the dorsal lip of the tibia in a clinical supination-eversion fracture is Stage 3 and

Fig. 5.—Same fracture as in Figure 4 after genetic reduction and application of "walking" plaster cast.

occurs after the oblique spiral fracture of the fibula and before the fracture of the medial malleolus, as was stated in the experimental-surgical investigations. The form and size of the clinical as well as the experimental fragment from the dorsal lip of the tibia vary greatly.

Dislocation.—Stage 2: The lateral malleolar fragment is often found to be dislocated 2 to 4 mm. laterally and dorsally, with the talus in valgus position; both are rotated outward in the anteroposterior view, in which their form deviates from the normal. The proximal fibular fragment is not dislocated, and it is especially to be noted that it is normally attached to the tibiofibular notch in dorsal subluxation of the talus.

Stage 3: In this stage the lateral malleolar fragment and talus are dislocated as in Stage 2, but in a more pronounced manner. Sometimes the talus is also sub-

luxated dorsally. The fragment of the dorsal lip of the tibia is often dislocated dorsally and proximally, with a step formation on the distal articular surface of the tibia.

Stage 4: The lateral malleolar fragment and talus are dislocated as in Stage 3, but the dislocation is even more pronounced and is present in all cases. There is often marked dorsal and proximal dislocation of the fragment of the dorsal lip of the tibia. The talus is then correspondingly subluxated dorsally and, together with the lateral malleolar fragment, is also dislocated proximally. At the same time they are rotated outward, in which position the lateral malleolar fragment can rotate somewhat behind the tibia, seen in the anteroposterior view as a dislocation of this fragment in a medial direction.

The medial malleolar fragment follows the medial surface of the talus and is dislocated laterally and ventrally, turned into valgus position, and rotated outward.

Reduction.—The right foot is grasped with the right hand around the middle part of the foot from the plantar and medial side, and with the left hand the heel region is grasped from behind. The foot is supinated and everted and is extended at the heel and plantar flexed (as in pulling off a boot).

The foot is then moved ventrally (under counterpressure against the anterior surface of the crus), inverted, pronated (still inverted as much as possible), and dorsiflexed to a right angle. A plaster cast is applied with the foot held in this position. While the plaster sets, the hind part of the foot is moved medially and adducted (the fore and middle parts of the foot being fixed while still pronated and inverted).

Explanation of the Reduction Maneuvers and the Maintenance.—When the foot is supinated and everted, the fracture surfaces are moved from each other.

When the foot is extended at the heel and plantar flexed, the proximal dislocation of the lateral malleolar fragment, the fragment of the dorsal tibial lip, and the talus is overcome because the intact ligaments between the talus-calcaneus and the lateral malleolar fragment will pull the latter in a distal direction and the intact ligaments between the lateral malleolar fragment and the fragment of the dorsal tibial lip pull at this.

When the foot is moved ventrally, the dorsal luxation of the talus and the dorsal dislocations of the lateral malleolar fragment and the fragment of the dorsal tibial lip are overcome by pull exerted by the same ligaments.

When the supinated foot is vigorously inverted, the inversion will produce the following effects: Partly that the talus is rotated inward in the malleolar fork, partly that the lateral malleolar fragment is pulled medially by the intact ligamentum talofibulare anterius, by which the lateral dislocation of both malleolar fragments, the lateral subluxation of the talus, and their external rotation are overcome.

When the foot is pronated (still inverted) and dorsiflexed to a right angle, the tightening up of the ligamentum talofibulare anterius is maintained, so that the fragments are kept in place.

When the hind part of the foot is adducted, the valgus position of the malleolar fragments and the talus, which may appear during the application of the plaster cast, is overcome.

If, after the reduction, the pronated foot is still subjected to inversion, the fragments cannot slip from each other and the tight-fitting plaster cast will secure the

position of the foot, and the position of the foot in relation to the crus, and thus the reduction is maintained and the fracture "locked."

The function of the plaster cast is thus to maintain the final position of the reduction, so that the foot is held dorsiflexed, pronated, and inverted to keep the fracture "locked."

All fractures should be reduced and dressed as described, even if roentgenologically there is only slight dislocation and external rotation, in order to obtain the proper turning of the talus helping in the reduction and the proper tension of the ligaments helping to maintain the reduction.

If this is not done, the result will be poor contact between the ends of the fractured bones, with ensuing delayed union or malunion owing to primary or secondary dislocation.

Fig. 6.—Pronation-abduction fracture, Stage 3. Notice (1) the characteristic localization and form of the fibular fracture decisive for this type of fracture (third lesion); (2) the fracture of the medial malleolus (first lesion, which is characteristic of the first stage if it is found isolated); (3) the fracture of the posterior lip of the tibia (second lesion, which is characteristic of the second stage if it is found in association with fracture of the medial malleolus only, i. e., without fibular fracture), and (4) the direction of the dislocation of the fragments and the talus (see text).

In Stage 1, however, it is necessary only to pronate, invert, and dorsiflex the foot while the plaster sets.

PRONATION-ABDUCTION FRACTURE, STAGES 1 TO 3

Genesis.—The cause of the pronation-abduction fracture is forced abduction of the hind part of the pronated foot.

Pathological Anatomy.—Stage 1 is fracture of the medial malleolus or detachment of the ligamentum deltoideum (with or without shell-shaped fragment).

Stage 2 is Stage 1 plus detachment of the ligamentum malleoli lateralis anterius with a small fragment anterolaterally and detachment of the ligamentum malleoli lateralis posterius and ligamentum malleoli lateralis posterius distale (the "transverse ligament") with a small or large fragment torn from the dorsal lip of the tibia. Stage 3 is Stage 2 plus an oblique straight-lined fracture of the supramalleolar part of the fibula.

Genetic Roentgen Diagnosis.—The genetic roentgen diagnosis is illustrated in Figures 6 and 7.

Dislocation.—Stages 1 and 2: The medial malleolus is dislocated distally and, together with the talus, turned into the valgus position. There is no, or only slight, dislocation of the fragment of the dorsal lip of the tibia.

Stage 3: Both the malleolar fragments and the talus are dislocated laterally, turned into the valgus position, and rotated outward. In the case of dorsal and

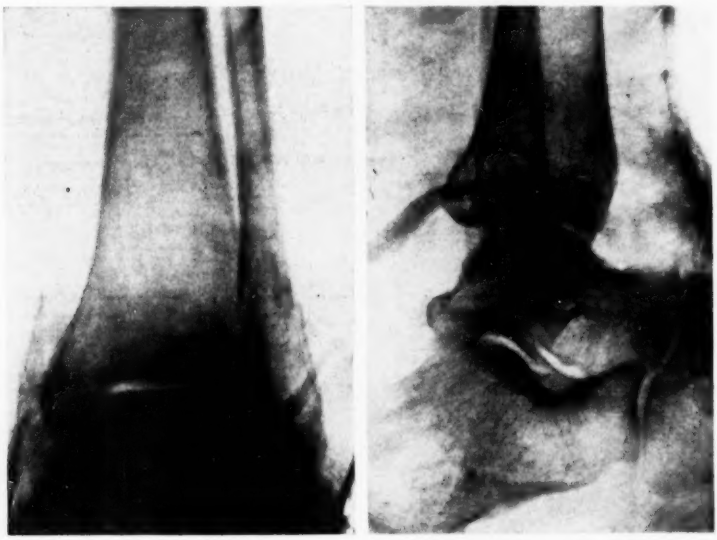


Fig. 7.—Same fracture after genetic reduction and application of "walking" plaster cast.

proximal dislocation of the fragment of the dorsal lip of the tibia, both malleolar fragments are dislocated and the talus in subluxation, together with the tibial fragment in the same direction.

Genetic Reduction.—The foot is grasped and the reduction carried out as in the supination-eversion fracture, but the final inversion should not be overdone. In Stages 1 and 2 the reduction is less complicated. It may be accomplished—after application of the plaster cast and while the plaster is setting—by adducting the hind part of the foot and by pronating the middle and fore parts of the foot under slight inversion.

PRONATION-EVERSION FRACTURE, STAGES 1 TO 4

Genesis.—The cause of pronation-eversion fracture is forced eversion of a pronated foot.

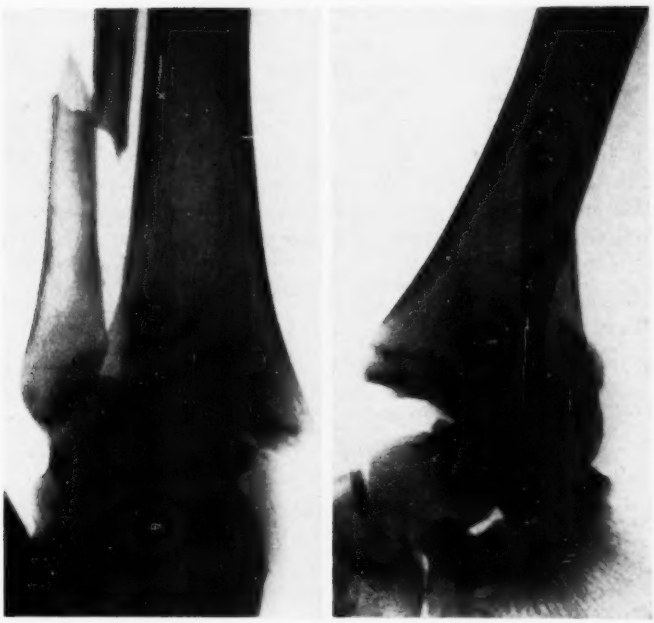


Fig. 8.—Pronation-eversion fracture, Stage 4. Notice (1) the characteristic localization and form of the fibular fracture decisive of this type of fracture (third lesion); (2) the fracture of the medial malleolus (first lesion, as in pronation-abduction fracture, Stage 1); (3) rupture of the ligaments of the syndesmosis (ligamentum malleoli lateralis anterius and ligamentum interosseum tibiofibulare) with attendant increase in the width of the syndesmotic space (second lesion; this lesion associated with fracture of the medial malleolus is characteristic of pronation-eversion fracture, Stage 2); (4) the fracture of the posterior lip of the tibia (fourth lesion), and (5) the direction of the dislocation of the fragments and the talus (see text).

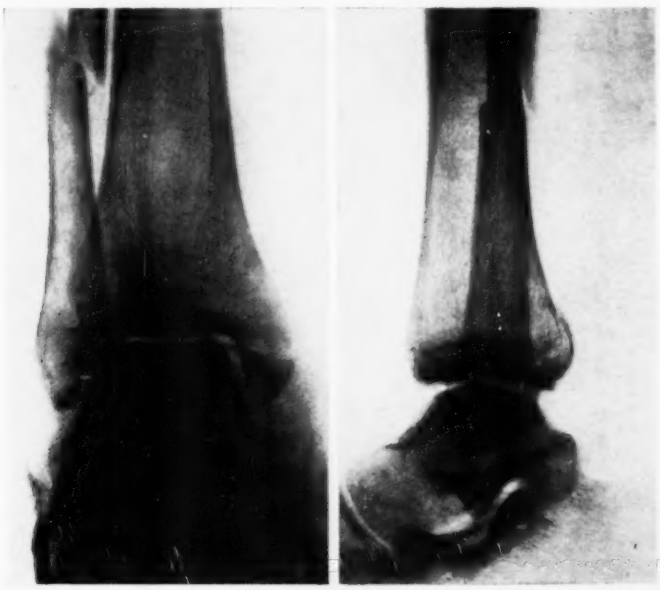


Fig. 9.—Same fracture as in Figure 8 after genetic reduction and application of "walking" plaster cast.

Pathological Anatomy.—Stage 1 is the same as in the pronation-abduction fracture. Stage 2 is Stage 1 plus detachment of the ligamentum malleoli lateralis anterius and the ventral part of the ligamentum interosseum tibiofibulare with a small anterolateral fragment from the tibia. Stage 3 is Stage 2 plus a spiral fracture of the fibula 6 to 8 cm. or more proximal to the tip of the lateral malleolus. Stage 4 is Stage 3 plus detachment of the ligamentum malleoli lateralis posterius and the ligamentum malleoli lateralis posterius distale with a small or large fragment torn off from the dorsal lip of the tibia.

Genetic Roentgen Diagnosis.—The genetic roentgen diagnosis is illustrated in Figures 8 and 9.

Dislocation.—Stage 2: The medial malleolar fragment is dislocated distally and turned into the valgus position together with the talus. The fibula is rotated outward, and thus the syndesmotic space is widened ventrally ("the door is opened").

Stage 3: In this stage the condition is the same as in Stage 2, only it is more pronounced.

Stage 4: In this stage the condition is the same as in Stage 3, only more pronounced. The fragment of the dorsal lip of the tibia is dislocated dorsally and proximally, thereby causing dorsal subluxation of the talus together with both malleolar fragments. By the external rotation of the malleolar fragments and talus, the lateral malleolar fragment may be dislocated behind the tibia (in the anteroposterior roentgenogram it appears as if it were dislocated medially), and the medial malleolus rotates ventrally and laterally.

Genetic Reduction.—Reduction is carried out in the same manner as in the supination-eversion fracture with the difference that the foot is first pronated and everted instead of being supinated and everted. The fragments and talus will thereby come into normal position, and the gaping syndesmotic space ("the open door") will be closed.

RADIOHUMERAL SYNOVITIS

MOORE MOORE Jr., M.D.
MEMPHIS

THIS PAPER is presented as an attempt to clarify what seems to many to be rather an obscure condition commonly referred to as "tennis elbow." The usual concept of this term is largely incorrect and misleading. The majority of articles dealing with the condition describe it as being epicondylitis (Cooper,[1] Dwyer and Murray [2]), an incomplete tearing of the fibers of origin of the forearm extensors (Hansson and Horwich,[3] Hansson [4]), or bursitis (Carp [5]). In general, these authors and others cited by North [6] in a collective review agree and further cite many other textbooks and authorities (McMurray, Mercer, Watson-Jones, Cyriax and Thomsen). The treatments recommended include manipulation, local procaine injection, limited activity, various splints, plaster immobilization and extensive physical therapy. Operation apparently is not recommended by them. It is to be noted that the lesion is extracapsular and will heal eventually whatever the treatment. However, in an appreciable percentage of cases the condition persists despite the use of the above-mentioned methods, and aggravation proportional to the amount of use of the elbow is noted. It is this group which will benefit from further investigation and about which this report is particularly concerned.

A few notable articles (Allen,[7] Latz,[8] and Stack [9]) have appeared in recent years which basically agree with the findings noted independently by the author. A review of the local anatomy shows that there is a mucosal half-curtain or fringe arising from the lateral synovial membrane of the elbow and lying interposed between the radial head and the capitellum (Grant [10]). When the elbow is flexed,

Read before the Section on Orthopedic Surgery at the One Hundredth Annual Session of the American Medical Association, Atlantic City, June 13, 1951.

1. Cooper, C. E.: Epicondylitis of the Humerus, U. S. Nav. M. Bull. **44**:501-506 (March) 1945.

2. Dwyer, F. J., and Murray, D. H.: Treatment of Epicondylitis: Review of 16 Cases, Permanente Found. M. Bull. **3**:8-11 (Jan.) 1945.

3. Hansson, K. G., and Horwich, I. D.: Epicondylitis Humeri, J. A. M. A. **94**:1557-1561 (May 17) 1930.

4. Hansson, K. G.: Epicondylitis Humeri, New York J. Med. **43**:29-33 (Jan.) 1943.

5. Carp, L.: Tennis Elbow Caused by Radiohumeral Bursitis; Anatomic, Clinical, Roentgenologic, and Pathologic Aspects with Suggestion as to Treatment, Arch. Surg. **24**:905-922 (June) 1932.

6. North, J. P.: Tennis Elbow: Collective Review, Internat. Abstr. Surg. **67**:176-179 (Aug.) 1938.

7. Allen, J. C. B.: Epicondylitis: Traumatic Radio-Humeral Synovitis, M. J. Australia **1**:273-274 (March) 1944.

8. Lahz, J. R. S.: Concerning Pathology and Treatment of Tennis Elbow, M. J. Australia **2**:737-740 (Dec.) 1947.

9. Stack, J. K.: Radiohumeral Synovitis, Quart. Bull. Northwestern Univ. M. School **20**:394-397, 1946.

10. Grant, J. C. Boileau: An Atlas of Anatomy, ed. 2, Baltimore, Williams & Wilkins Company, 1947, p. 47, fig. 53.

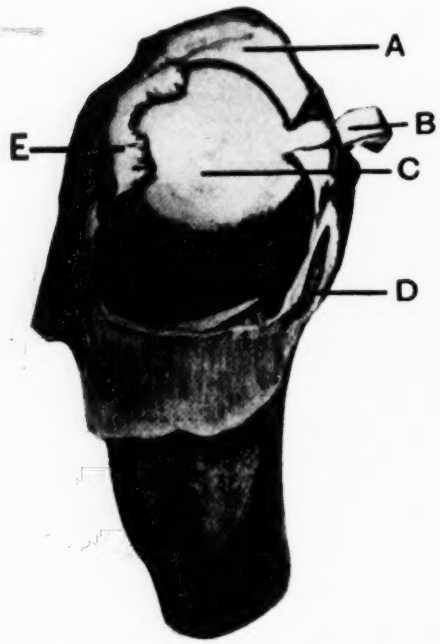


Fig. 1.—Circular fold on head of radius. The fold in this specimen is fibrocartilaginous (adult). *A*, fold; *B* portion reflected to show thickness; *C*, head of radius; *D*, annular ligament; *E*, interposed synovial membrane, subject to pinching. (Reprinted from the *British Journal of Surgery*, vol. 18, no. 72, 1931.)

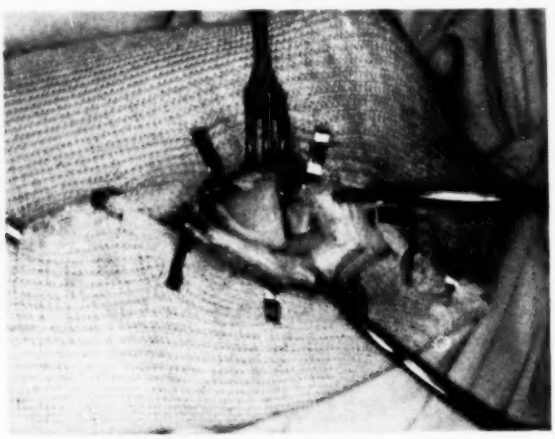


Fig. 2.—Typical operative findings showing thickened edematous mucosal flap.

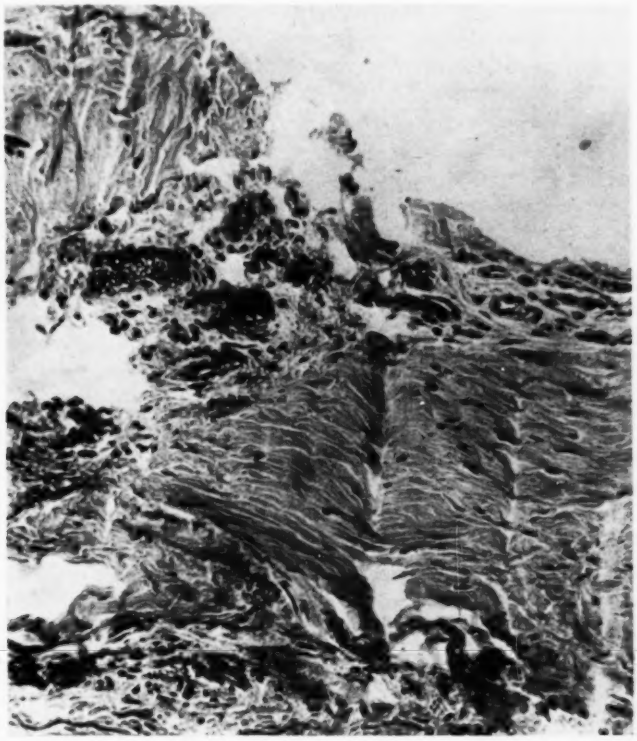


Fig. 3.—Representative microscopic findings showing chronic irritative reaction.

Fig. 4.—Characteristic roentgenogram, normal except for minute extra-articular calcification opposite the joint. The lesion, however, was intra-articular.

these articular surfaces are not in contact, but extension, especially when combined with supination, brings them into close apposition. Forceful supination, as by the strong brachioradialis in resisted motion, makes this apposition much greater. The mucosal flap or membrane is thus pinched repeatedly in varying degree in normal daily activity. Such repetitious minor trauma will inevitably produce hyperemia and edema which leads to subsequent thickening and villous formation. In addition, the membrane becomes more friable and thus is more subject to partial tearing. Occasionally if the initial trauma is sufficient a tear may result at first. A vicious cycle is then established. This characteristic pathology is shown in Figures 2 and 3.

I have operated on 10 patients and have observed almost identical gross as well as microscopic findings in each. The histories and physical findings are so nearly alike that they will be summarized. It is interesting that all have occupations requiring heavy use of the elbow, namely, highway foreman, waitress, automobile mechanic, contractor, naval aviation diesel mechanic, housewife, railway mail clerk, farmer. It also seems pertinent that the ages range from 35 (waitress) to 50 years (mechanic) and that males have a 5 to 1 preponderance. The women's occupations are ones in which minor trauma abounds. Six patients have been observed who have not yet come to operation; of these, two are nurses, two are housewives, one is a golfer (her left elbow is involved), and one is a doctor.

The chief complaint is pain localized to the radiohumeral joint, noted on extension of the elbow and supination of the forearm. Resistance increases the pain. Occasionally crepitus is noted with this maneuver. I have been unable to note a mass such as Allen [7] describes. Mild wasting from disuse of extensor musculature is usually seen. The radiohumeral joint itself has pinpoint tenderness to pressure which is made worse by extension and supination of the elbow. The lateral humeral epicondyle and radial head are usually not tender. Roentgenograms are negative although occasionally a small calcific deposit is seen lateral to the joint (Fig. 4). The usual laboratory procedures give no help.

The preferred treatment is operative removal of the thickened and probably torn synovial membrane. The procedure is easy, the period of hospitalization is short, and complete immediate relief can almost certainly be promised the patient. No recurrences have been experienced, and no complications have developed. The day after surgery active motion is started and stepped up progressively. No splinting is desirable, and no special after-care other than active use is required. Nearly all patients encountered have been to several other doctors, have undergone various treatments without relief, and are most grateful.

SUMMARY

Literature pertinent to the so-called "tennis elbow" has been reviewed briefly. The general concept usually associated with the term "tennis elbow" is thought to be misleading and incomplete. A condition which is believed to be a major cause of persistent radiohumeral pain is described, along with the mechanism of production of the basic pathologic process.

Foreign observers seem to be more aware of this condition and its proper treatment than we in this country.

The use of a method which gives prompt relief is urged.

ABSTRACT OF DISCUSSION

DR. MILTON C. COBEY, Washington, D. C.: The author has given a clear picture of acute synovial irritation of the elbow joint in a condition often called either "tennis elbow" or epicondylitis. The idea of a congenital sheath or fold of synovia existing in some persons into adult life is verified in Grant's anatomy book. That this sheath may become inflamed from some acute trauma or from repeated minor trauma is a good explanation for the cause of some cases of epicondylitis or "tennis elbow."

After reviewing the articles referred to by the author and the cases which I have encountered, I feel that the cause of this disease syndrome is multiple. It is not always possible to separate "tennis elbow" and epicondylitis as two entities, one a bursitis and the other an inflammation of the epicondylar tissue, or the causes thereof. The true existence of a radial head bursa was first described by Dr. Osgood. It can be injected or excised when it becomes inflamed. The bursa can be demonstrated by x-ray calcification.

Besides the calcific bursitis, there is also, I believe, a noncalcified bursitis of the radiohumeral joint such as is encountered in the shoulder joint. Acute injury, associated possibly with rupture of the radiohumeral ligament, or part of the aponeurosis, will also produce pain about the epicondyle.

Adhesions about the capsule have been described, and these are treated by manipulation and pain again relieved in this area. Synovial folds or synovial tags, as described by the author, undoubtedly exist and then become inflamed just as they would in any other joint. Certainly the removal of these would bring about relief in the radiohumeral joint. The release of the compression mechanism in the radiohumeral joint, however, is an interesting factor here. Inflammation is present in these cases. We have been in the past surgically joining the wrist extensor muscle origin at the epicondyle. This procedure releases the compression force in the radiohumeral joint and often brings about relief.

In cases in which relief is not brought about by manipulation, physical therapy and rest, and if roentgenograms do not reveal any other abnormalities such as calcification, exploration should be done and the painful tags and nodules removed.

The author is to be congratulated for adding to our knowledge another solution to this difficult problem.

DR. D. C. CONZETT, Dubuque, Iowa: It would seem that manipulation in this particular entity is to be discarded, if the findings which Dr. Moore presented in the films are factual. If, as he brought out in the paper, the pathology that is involved is that of hyperemia and edema, probably our older concept of rest is of value. Certainly, the combination of local procaine injection with splinting and rest will tend to alleviate the condition existing. The operation suggested, along with removal of synovial membrane that was evident, is the treatment of choice.

I agree with the previous discusser that possibly a brief course of conservative management, followed by the treatment suggested by Dr. Moore, would be of value.

DR. WALTER P. BLOUNT, Milwaukee: Dr. Moore has modestly called our attention to a definite pathologic entity. Only in cases in which there is distinct localized "point" tenderness directly over the radiohumeral joint should this operation be attempted. If a synovial fold has been causing the symptoms, the relief is dramatic.

CONSERVATIVE TREATMENT OF FRACTURES OF THE TIBIAL PLATEAU

CARL E. BADGLEY, M.D.
AND
SYLVESTER J. O'CONNOR, M.D.
ANN ARBOR, MICH.

COMPLETE restoration of function has always been the ultimate goal in the treatment of fractures and joint injuries. The conservative treatment of fractures of the lateral tibial plateau has in our experience produced an excellent functional result.

Mikkelsen [1] has classified 18 types of fracture involving the proximal articular surface of the tibia. However, three types of fractures generally occur in the lateral plateau, as follows: (1) a large single fragment involving the articular cartilage that is depressed and laterally displaced; (2) severe compression with downward displacement of the articular surface of the tibia into the body of the tibia, and (3) lateral displacement of the main fragment with central depression.

In 1929 Cotton [2] described fractures of the lateral tibial plateau as "bumper" or "fender" fractures since these were the commonest mechanisms of injury. He believed that treatment should consist in manipulation and support rather than in surgery. Since then a number of excellent articles have been written advocating one or the other method.

The mechanism of injury is rather constant. When the femoral condyle is forcibly thrust against the lateral tibial plateau in an abduction injury of the knee, the supporting ligamentous structures must give way or a fracture will result. The force is usually severe enough to produce both soft and bony-tissue injury. Although the automobile accounts for most of them, these injuries frequently follow falls from ladders, porches, and scaffolds. If, in a fall on the extended knee, an abduction force does not occur, then both tibial plateaus are compressed in the shattering derangement, in which instance the injury is considerably severer.

The presence of one of these fractures can usually be recognized when the patient is first seen. The knee is intensely swollen, and often a valgus deformity is present. It may be impossible to examine the joint adequately because of pain produced by motion. However, if force is gently applied to the collateral and cruciate ligaments, one may frequently demonstrate instability. Roentgenograms will suggest the extent of bony injury. Cubbins [3] recommends serial views of the joint

Read before the Section on Orthopedic Surgery at the One-Hundredth Annual Session of the American Medical Association, Atlantic City, June 15, 1951.

1. Mikkelsen, O.: Intraarticuläre Frakturen des obersten Tibiaendes, Acta chir. scandinav. **73**:1-41, 1933.

2. Cotton, F. J., and Berg, R.: New England J. Med. **201**:989-995, 1929.

3. Cubbins, W. R.; Conley, A. H.; Callahan, J. J., and Scuderi, C. S.: Fractures of Lateral Condyle, Surg., Gynec. & Obst. **59**:461-468.

for better determination of the degree of fracture. Most surgeons agree that the extent of injury produced in the joint is considerably more than is demonstrated by the roentgenograms.

Usually more damage is found at the time of arthrotomy than might have been suspected preoperatively. This has been advanced as one of the important reasons for recommending exploration of the joint. Leadbetter [4] and Palmer [5] have been especially adamant on this point. It is their opinion that it is impossible to restore adequate joint congruity by any of the manipulative methods.

It is often stated that the lateral semilunar cartilage is centrally depressed and becomes in itself sufficient cause for internal derangement of the joint. On the other hand, those who have used manipulative or splint methods in caring for these fractures have not been impressed with the need for surgical removal of the cartilage. In fact, the lateral meniscus usually acts as a cushion to hold the femoral condyle from further compressing the tibial articular surface. It is a contention of the advocates of surgical repair of these fractures that it would be impossible to replace the comminuted fragments in an effort to form an adequate joint line by nonsurgical means. We believe that it is mechanically unfeasible to attempt replacement and internal fixation of these fragments with any assurance that the articulating surfaces will remain intact.

For a number of years we have used both methods of treatment. If one single fragment seemed to exist, then operative fixation of this to the main body of the tibia seemed the most expedient way of restoring joint congruity and hope for the best possible function. Again, only if the central area of the articulating surface were depressed and the peripheral area showed no evidence of downward or lateral displacement did it seem logical to elevate this part operatively and hold it in place by use of a bone graft. It was also found that by the use of two Steinmann pins, one placed through the distal femur and one through the proximal tibia and using pin distractors to separate the joint surfaces, good reduction could be obtained, with satisfactory function resulting.

No matter what the method of treatment, the following aims must be fulfilled: 1. Valgus deformity must be corrected. 2. Subluxation of the joint must be reduced. 3. Lateral displacement of the plateau must be corrected. 4. Supporting soft tissues and ligaments should be allowed to heal. 5. The strength of the quadriceps musculature should be developed beyond that of the normal side to increase the stability of the joint.

Realizing that pin distraction with cast fixation gave good results in some fractures, we decided to use skeletal traction and to incorporate early active exercise in our program of treatment. We are presenting a series of 17 patients for whom this method of treatment has been used. After the roentgenograms have been reviewed, a Kirschner wire is inserted, with the patient under local procaine anesthesia, through either the distal tibia and fibula or the os calcis. The extremity is then placed in a Thomas leg splint, with a Pierson attachment and 10 to 15 lb.

4. Leadbetter, G. W., and Hond, F. M.: Fractures of the Tibial Plateau, J. Bone & Joint Surg. **22**:559-568, 1940.

5. Palmer, I.: Compression Fractures of Lateral Tibial Condyle and Their Treatment, J. Bone & Joint Surg. **21**:674, 1939.

(4.5 to 6.8 kg.) of traction. The knee is in about 14 to 20 degrees of flexion. The traction is at first fixed to prevent motion at the knee until the acute symptoms have subsided (Fig. 1). After the extremity has been placed in the splint, the knee joint is aspirated in order to relieve the pressure resulting from the hemarthrosis. The pressure accounts for a great deal of the pain, and its removal is followed by considerable relief. The procedure may be repeated daily if necessary until bleeding has subsided. This is clearly bone-marrow bleeding, as evidenced by the supernatant fat present in aspirated specimens which are allowed to settle for a period of several hours (Fig. 2).

It is not our intention to treat all fractures of the lateral tibial plateau by this method, but complicating factors in several cases have made it the method of choice.

The patients are held in traction for a period of from 8 to 12 weeks, depending on the nature of the fracture and on the stability of the knee joint. Within 24 to 48 hours vigorous active quadriceps exercises are instituted and continued throughout the course of treatment, including the full weight-bearing period. In one to two weeks' time active and passive exercises are begun by means of the Pierson attachment, with special attention directed toward correcting the valgus deformity by progressively adducting the attachment. When, through clinical examination, it is found that the knee is stable in extension and bony angulation is corrected, the extremity is removed from the splint and placed in either a bivalved cast or a long double upright caliper. In either event, no, or partial, weight bearing is recommended for a further period of two to three months until bony union is present (Fig. 3).

Case 1 (Fig. 4).—M. S., a woman aged 57, fell from her porch to the ground and injured the right knee and ankle on May 25, 1948. Roentgenograms demonstrated a lateral plateau fracture and a trimalleolar fracture of the ankle. A pin was placed through the os calcis and the leg held in traction for 8 weeks and then in a long double upright caliper for 12 additional weeks. In May, 1951, the patient had excellent knee motion without pain, stable, minimal valgus deformity, and motion from 175 to 75 degrees.

The valgus deformity might have been obviated if more attention had been directed toward original correction. On the other hand, Cubbins stated that most of the patients end up with a tedency toward valgus deformity. Dobelle[6] has described an ingenious method of correcting the valgus deformity through use of an anterior-posterior hinge at the knee joint in a long leg cast.

Case 2 (Fig. 5).—I. B., a woman aged 29, and weighing 220 lb. (99.8 kg.), on July 15, 1948, fell from a ladder and landed on the ground with the right knee in extension. Clinical and x-ray examination showed a single laterally displaced fragment of the tibial plateau. Operative fixation was decided on, but thrombophlebitis developed and surgery seemed contraindicated. The leg was placed in balanced skeletal traction for 8 weeks and then in a bivalved cast, non-weight-bearing, for an additional 12 weeks. The patient now has a full range of motion without pain or deformity.

Case 3 (Fig. 6).—H. G., a man aged 62, fell from a scaffold, landing on his extended right knee, and suffered a fracture dislocation of the right knee. X-ray examination demonstrated

6. Dobelle, M.: A New Method of Closed Reduction of Fracture of the Lateral Condyle of the Tibia, Am. J. Surg. **53**:460-462, 1941.

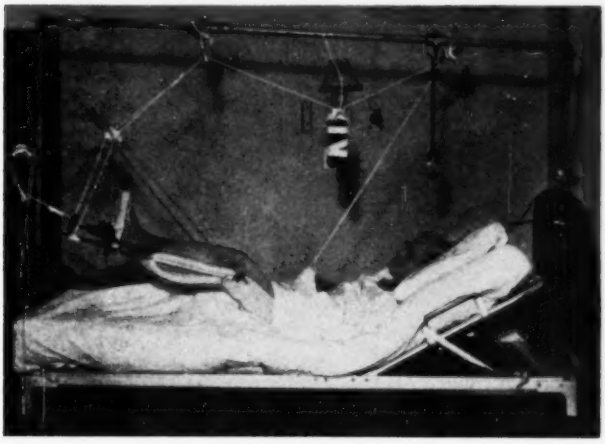


Fig. 1.—Skeletal traction through the distal tibia and fibula is used to reduce and immobilize the plateau fractures. By mobilizing the Thomas splint, knee-joint motion is instituted.

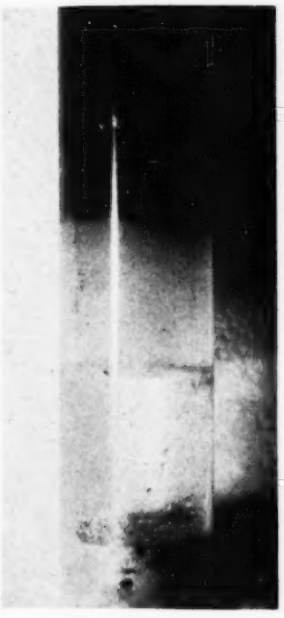


Fig. 2.—A tube of aspirated joint fluid demonstrates blood and supernatant fat.

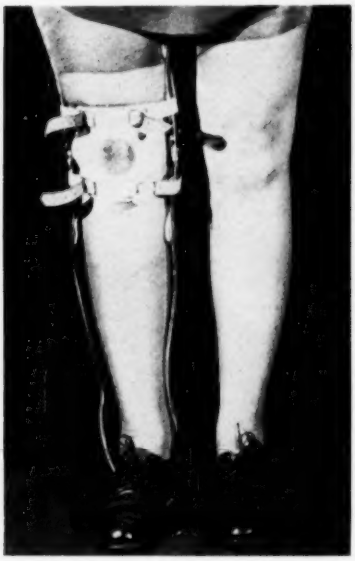


Fig. 3.—A long double upright caliper is used to support the knee after traction until healing of the fracture has occurred.

Fig. 4 (M. S.).—Roentgenograms demonstrate comminuted lateral tibial plateau with medial plateau intact. Patient now has minimal valgus deformity, with good range of motion without pain.

Fig. 5 (I. B.).—Single fragment of lateral plateau was reduced with traction. Patient now asymptomatic. This might well have been fixed in place operatively with an equal result.

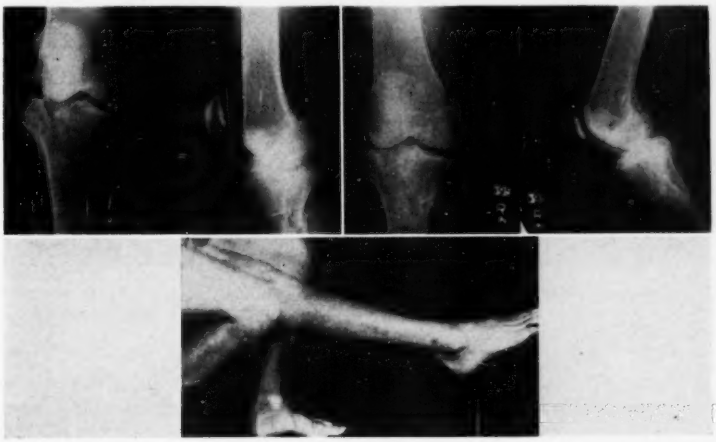


Fig. 6 (H. G.).—Comminuted fracture of lateral plateau with subluxation of knee. At present there is no deformity, full motion, and no pain.

severe comminution and depression of the lateral tibial plateau. The leg was placed in traction for a period of 12 weeks and then in a long double upright caliper. By April, 1951, the patient had an excellent, painless range of motion of the knee joint without deformity.

Case 4 (Fig. 7).—H. S., a man aged 44, on Oct. 25, 1948, fell 12 ft. (660 cm.) from a scaffold and landed on his extended left lower extremity. X-ray examination revealed extensive comminution of the lateral plateau. One hundred thirty cubic centimeters of blood was aspirated from the joint. The extremity was placed in balanced traction. On October 29 phlebothrom-

Fig. 7 (H. S.).—Severely comminuted fracture showing, at present, intact medial plateau with depression of lateral plateau. Debilitating arthritic changes likely to develop. Patient is at present asymptomatic.

bosis developed. Nine weeks later the leg was placed in a bivalved cast. Weight bearing was not permitted for six months. In May, 1951, there was extension from 175 to 75 degrees, with no instability or valgus deformity. The patient has returned to work as a roofer.

This patient would have been operated on, with elevation of the fragments, had not the venous occlusion developed. At present the functional result is excellent. Whether it could have been improved by surgery is certainly debatable.

CASE 5 (Fig. 8).—M. D., a woman aged 55 and weighing 185 lb. (84 kg.) fell from the steps of a porch on June 30, 1948, and landed on her extended right knee. Examination showed a compression fracture of the tibial plateau. X-ray examination revealed an extensive fracture. The leg was placed in elevated balanced traction, with the knee in 160 degrees of extension. Five days later phlebothrombosis had developed, which subsided with anticoagulant therapy. The leg was held in traction for nine weeks and was non-weight-bearing in a long double upright caliper for 10 additional weeks. At present there is good range of motion without pain. The patient works nine hours a day as a cook. She has residual swelling from the venous occlusion, which is controlled with the use of an elastic stocking.

Fig. 8.—Comminuted fracture of lateral plateau with lateral displacement. Patient has residual swelling secondary to phlebothrombosis but otherwise a good, functioning knee joint.

COMMENT

In this group of 17 patients, some evidence of venous occlusion developed in 6 as evidenced by pain and swelling in the leg distal to the site of injury. It is interesting that this swelling occurred in all those who had direct trauma to the tibia as a result of a fall. In only one case has there been any residual swelling (I. B.). In all cases there is at least 100 degrees of knee-joint motion. Although the longest follow-up in this group is three years, none of the patients have what would be classed as a poor result.

In this group of cases, symptoms referable to torn or displaced menisci have not been apparent, the presence of which has been considered one of the main indications for arthrotomy. Certainly one cannot say that as time goes on varying degrees of degenerative arthritic changes will not develop, since they usually result in any severely traumatized joint.

As time has passed, we have realized more and more the necessity for vigorous quadriceps exercises in an attempt to obtain maximum knee-joint stability. Even in the presence of some degree of ligamentous relaxation, the patient will not be bothered by the troublesome sensation of his knee "giving way" if this musculature has been developed to a sufficient degree. Part of each outpatient visit during the follow-up period is spent in reinstructing the patients in their exercises and in explaining the necessity for continuing them.

The prognosis must be partially dependent on the patient's age, ability to cooperate in treatment, severity of osseous and soft-tissue injury, and, unfortunately at times, on whether or not compensation is involved in the case. Mikkelsen showed tremendous variation in his results of nonoperative treatment, seemingly depending almost entirely on this last point.

SUMMARY

From a study of this group of patients it becomes apparent that operative correction is not necessary in all cases of fractures of the lateral tibial plateau to obtain a good functional result. On the other hand, certain centrally displaced fractures or single fragments are best treated by open reduction.

ABSTRACT OF DISCUSSION

DR. JOHN R. MOORE, Philadelphia: This is an interesting paper and well controlled. The results speak for themselves. I am going to needle Dr. O'Connor and Dr. Badgley because in their conclusions there are no poor results. The title of the paper is misleading to me because it implies that both the medial and the lateral plateaus are included, yet the material and treatment and conclusions would seem to be directed essentially to the lateral plateau. This point should be clarified.

Seventeen patients with plateau fractures have been treated by what I choose to call "pot-luck traction." There have been no poor results. All the patients have returned to their original occupation, satisfied and happy, with no instability in extension, a stronger quadriceps on the injured side than on the normal, and no evidence of traumatic arthritis in the three-year follow-up. To the best of my knowledge, these are the best results obtained by the open or closed method of treating the fractures presented to date.

These results have not just happened, however, but are due to the intense intelligent application of sound orthopedic and surgical principles. The first of these is immediate and adequate immobilization and then paracentesis of the knee to relieve pressure from fluid within it, and thereby save needless and harmful ligament distention, and to relieve pain. The second is attention to early training of quadriceps and hamstring muscles. The future of the knee depends almost wholly on these structures, in many instances. The knee joint motion is begun early and is supervised most carefully. Last, but not least, is the protection of the relatively soft cancellous bone of the tibial tuberosities against pressure. This is done with traction during the period in bed and with brace and crutches during the early weight-bearing period, up to six months. Cancellous bone at the knee, in the os calcis, the head of the femur and elsewhere is noted for its gradual settling and must be protected from full weight for at least six months.

To the above, add the restoration of alignment and of the articular surface and the alignment of the tibia on the femur, especially, eliminating knock knee, and you have a composition that can hardly be questioned. As the authors have pointed out, the outlook, though somewhat grave, depends on the degree to which these requirements are met. I, too, feel that the central depressed fragment should be openly reduced. I am in full accord with the principles of conservative treatment, although I have not had the remarkable success of the authors. I am beginning to absorb some of their optimism and hope to live and learn.

DR. JOHN T. JACOBS, Denver: Dr. O'Connor has stated that complete restoration of function is the goal. There is, however, a factor that is becoming more important to all of us. That is the economic side of these fractures and the time loss that the patients suffer.

I should like to present two cases. The first patient was treated elsewhere.

(Slide) This is a medial plateau fracture. Now I should like to point out the disability and the unsatisfactory side of this case. In the first place, two years after the fracture shown here in the roentgenogram, the patient had no loss of motion, good muscle power, and no complaint of pain. He was working as a farm laborer on rough ground, with the only complaint that when he lifted 100-lb. (45 kg.) sacks of potatoes he felt a strain on the knee. There was approximately 6 in. (15 cm.) of bowing, and he felt as though the knee would give way, but it did not.

(Slide) Osteotomy was performed, with a block of bone placed in, as you see, restoring the leg length and straightening the bow leg, at least to a marked degree. He still has the full range of motion, no complaint of pain, good muscular development, and no sensation of strain or instability.

(Slide) This fracture was treated by us. No one on the service felt that he wanted to attempt open reduction.

(Slide) This shows the picture a year and a half later. The patient had disability for a year and a half. He recovered and is now working as a meat cutter, with no complaint about the knee.

You will find that recovery will be delayed when you are forced to use conservative treatment. When you believe that you can improve the anatomy of the tibial plateau structures, you should attempt to do it by open reduction. When joint structure is improved, instability will be decreased and less time lost.

DR. SYLVESTER J. O'CONNOR, Ann Arbor, Mich.: I appreciate the discussers' opinions, and I am not at variance with any of them. We had no point to make other than to say that fractures of the tibial plateau, and especially the lateral, would give good functional results if treated by this method, which we consider to be conservative.

I agree with Dr. Moore that the time in these cases is entirely too short to say that there will not be significant difficulty in the future. On the other hand, one cannot say that the same sequela would not have developed if operation had not been performed. So far as aspiration of the knee is concerned, I realize that you are converting a simple fracture into a compound fracture. The reason we have carried out aspiration is that in our experience the patients have been tremendously more comfortable than before aspiration.

SURGICAL EMERGENCIES RESULTING FROM CORPUS LUTEUM CYSTS AND HEMATOMAS

TOKUSO TANIGUCHI, M.D.
JACK A. KLIEGER, M.D.
AND
MICHAEL J. KUHN, M.D.
MILWAUKEE

THE DEVELOPMENT of a small corpus luteum cyst or hematoma in the ovary is not uncommon, for varying degrees of hemorrhage and cystic enlargement normally occur during the menstrual cycle or during pregnancy. The majority of these cysts and hematomas regress spontaneously without producing clinical symptoms. A few, however, enlarge beyond the norm, become pathological, and create surgical emergencies of various natures.

Emergencies resulting from corpus luteum cysts and hematomas are not too uncommon, although relatively few reports have appeared in the literature. In most of the reported cases the complications have been due to rupture of the corpus luteum with resulting hemoperitoneum. Few isolated cases of other types of complications have been described.

In an attempt to summarize the various surgical complications that result from a corpus luteum, the following study was undertaken. It comprises a review of material from the departments of surgery and gynecology of St. Joseph Hospital, Milwaukee, covering a period of five and one-half years, between January, 1946, and June, 1951. During this period a total of 71,792 persons were admitted to the hospital, of whom 24,146 were obstetrical patients and 4,706 were gynecological patients. Among the 28,852 obstetrical-gynecological patients, 20 surgical emergencies, of four major types of complications, resulting from corpus luteum cysts and hematomas were encountered. In 16 cases rupture of the corpus luteum was responsible, in 2 strangulation by torsion of the ovarian pedicle, in 1 obstruction of labor, and in 1 a marked cystic enlargement producing abdominal distention. In the last case, a corpus luteum cyst of pregnancy grew to a huge size during gestation so that its surgical removal, after the delivery of the infant through the normal route, was necessary.

The ovarian pathology in all these cases was confirmed by microscopic examination of the specimen submitted to the laboratory.

From the departments of surgery and gynecology, St. Joseph Hospital, and the Marquette University School of Medicine.

ANALYSIS OF CASES OF RUPTURED CORPUS LUTEUM

The age of the patients ranged from 13 to 45 years (Table). Three were under 20 years, 11 were between 20 and 29 years, 2 were between 30 and 39 years, and 1 was over 40 years of age. The average age was 26. Fourteen patients were married, and three were single. Rupture of the corpus luteum occurred anywhere between the 16th and the 29th day of the menstrual cycle, with the majority occurring between the 21st and the 24th day. In three cases, rupture occurred during pregnancy, in two at five weeks' gestation and in the other at eight weeks. In all 17 cases, except one, the condition was misdiagnosed preoperatively, as acute appendicitis (11 cases), ectopic pregnancy (3 cases), or simple cystic ovary (2 cases). This preponderant error in diagnosis, especially the confusion with acute appendi-

Surgical Complications of Corpus Luteum Cysts and Hematomas

Patient	Age, Yr.	Corpus Luteum	Diameter of Cyst, Cm.	Ovary	Preoperative Diagnosis	Operative Findings
L. S.	19	Ruptured cyst	2.3	R	Acute appendicitis	Hemoperitoneum
M. F.	19	Ruptured hematoma	3.5	R	Acute appendicitis	Hemoperitoneum
J. A.	29	Ruptured cyst	2.0	L	Cystic ovary	Hemoperitoneum
L. F.	21	Ruptured cyst	2.0	R	Acute appendicitis	Hemoperitoneum
D. O.	27	Ruptured hematoma of pregnancy	3.1	R	Acute appendicitis	Hemoperitoneum
J. H.	22	Ruptured hematoma	2.5	R	Ectopic pregnancy	Hemoperitoneum
L. E.	34	Cyst of pregnancy	8.0	R	Obstructed labor	Cyst obstructing labor
L. S.	21	Ruptured hematoma	2.0	L	Acute appendicitis	Hemoperitoneum
R. W.	45	Ruptured hematoma	2.0	L	Acute appendicitis	Hemoperitoneum
J. Y.	13	Strangulated cyst with rupture	6.0	R	Acute appendicitis	Hemoperitoneum, strangulated cyst
M. M.	28	Cyst of pregnancy	18.0	L	Ovarian cyst	Tremendously enlarged cyst
M. A.	26	Ruptured hematoma	2.0	L	Acute appendicitis	Hemoperitoneum
G. K.	26	Ruptured hematoma	2.5	R	Acute appendicitis	Hemoperitoneum
R. L.	30	Ruptured hematoma	3.0	R	Ruptured corpus luteum	Hemoperitoneum
L. E.	33	Ruptured cyst of pregnancy	3.0	R	Ectopic pregnancy	Hemoperitoneum
J. K.	28	Ruptured hematoma	5.0	L	Acute appendicitis	Hemoperitoneum
V. H.	29	Ruptured cyst	4.5	R	Cystic ovary	Hemoperitoneum
E. W.	29	Ruptured cyst	2.5	R	Acute appendicitis	Hemoperitoneum
M. Y.	28	Ruptured cyst of pregnancy	3.0	L	Ectopic pregnancy	Hemoperitoneum
R. W.	21	Twisted cyst of pregnancy	3.0	R	Acute appendicitis	Cyst twisted 180°

citis, was probably due to the fact that rupture occurred in the right ovary in 11 cases.

Free blood was present within the peritoneal cavity in all the cases. It varied in amount from a few cubic centimeters to "an abdomenful." In most of the cases, the blood was localized to the pelvic cul-de-sac, and in others it was generalized. In two cases, the blood extended up to the diaphragm and produced referred pain to the shoulders by irritation of the phrenic nerve. Active bleeding from the ruptured corpus luteum was still present in several of the cases at the time the abdomen was opened.

Abortion occurred in the five-week pregnant woman (Case 5, Table) after oophorectomy. It was necessary to extirpate the entire ovary in this patient because there was strangulation of the organ by torsion of its pedicle in addition to the rent present in the corpus luteum cyst from which active bleeding was taking place. In the other two pregnant women, at eight and five weeks' gestation (Table), pregnancy continued uneventfully after oophorectomy.

REPORT OF CASES

CASE 1.—*Ruptured corpus luteum producing hemoperitoneum*

L. S., a 19-year-old married woman, was admitted to the hospital on Jan. 8, 1946, with the chief complaint of persistent abdominal pain of 24 hours' duration. The pain, which developed suddenly in the lower abdomen, was described as being "cramping" in nature. It later became generalized. The pain was then felt in the chest and in the shoulder and was aggravated by deep respiration. The patient became nauseated but did not vomit.

Her last menstrual flow was on Dec. 15, 1945. Her previous periods had been regular, and the bleeding was of three to six days' duration, with dysmenorrhea on the first day.

Examination showed that the patient was in some pain but in no acute distress. The abdomen was soft, flat, and nonrigid but tender around the umbilicus and in the lower quadrants. Rebound tenderness was fairly marked. The bowel sounds were normal. A bimanual pelvic examination revealed some tenderness in the adnexa, but no definite mass was palpable. The uterus was normal in size and position. The hemogram read as follows: 3,370,000 erythrocytes and 10,550 leucocytes, with 2% stab neutrophiles, 74% segmented neutrophiles, 16% lymphocytes, and 8% monocytes.

The patient was observed for two days. Pain and tenderness persisted, and therefore the abdomen was explored. The peritoneal cavity was found filled with a large amount of free blood. Dark clotted blood was present in the pelvic cul-de-sac. Both ovaries were cystic and hemorrhagic. A rent, about ½ in. (1.3 cm.) long, was present in the right ovary. The ruptured ovary was removed.

The pathological diagnosis was ruptured corpus luteum cyst.

The postoperative course was smooth, and the patient was discharged on Jan. 18, 1946.

The clinical and physical findings in this case were fairly typical of a ruptured corpus luteum with massive hemoperitoneum. The sudden onset of abdominal pain in the second half of the menstrual cycle and the finding of a soft, flat, nonrigid but tender abdomen with rebound tenderness were suggestive of free blood in the peritoneal cavity originating from a ruptured corpus luteum. Pain was referred to the shoulder, apparently by the blood extending up to the diaphragm and irritating the phrenic nerve.

CASE 7.—*Corpus luteum cyst obstructing labor*

Mrs. L. E., a 34-year-old secundigravida, nullipara, at term, was admitted to the hospital on July 27, 1948, in labor. Examination showed the fetus lying diagonally in the abdomen, with the presenting vertex unengaged and lying over the left iliac fossa. The membranes were intact, and the cervix was not dilated. Rectal examination revealed a rounded mass in the posterior cul-de-sac.

Labor continued irregularly for 20 hours without engagement of the head. A roentgenogram taken at this time showed the head deflected to the left, unengaged, and over-riding the symphysis pubis (Fig. 1).

A diagnosis of obstructed labor was made, and a Caesarean section was performed, with the delivery of a normal infant. In the posterior cul-de-sac there was a large thin-walled cyst, the size of a grapefruit, slightly twisted on its pedicle. It arose from the right adnexa. The cyst was extirpated.

The patient made an uneventful recovery and was discharged on the ninth postoperative day.

The pathological report was corpus luteum cyst of pregnancy (8 cm. in diameter).

It is surprising that the thin-walled cyst did not rupture during labor. Had it ruptured, it would be interesting to speculate about the subsequent course of the labor. Would the infant be delivered spontaneously from below without appreciable intraperitoneal hemorrhage, or would the rupture result in massive bleeding and thus necessitate an immediate laparotomy?

CASE 11.—*Giant corpus luteum cyst of pregnancy*

Mrs. M. M., a 28-year-old trigravid biparous woman, was first seen on July 15, 1949, during the eighth month of pregnancy, and at this time a large cystic tumor was noted lying on the upper surface of the pregnant uterus. The past history of the patient was essentially noncontributory. She had been married nine years and had borne two normal children, four and seven years ago. The first delivery was by breech extraction. The menarche occurred at age 13, and the menstrual periods were fairly regular (30-day-intervals) with a moderate amount of flow lasting about 3 days.

A roentgenogram of the abdomen taken on July 15, 1949, did not demonstrate the cyst but showed the fetus pushed downward into the pelvis and displaced anteriorly in a transverse position.

The pregnancy went to term, in spite of compression and displacement, and a normal infant weighing 6 lb. 12½ oz. (3,060 gm.) was delivered spontaneously through the vaginal route on Aug. 9, 1949. The duration of labor was 4 hours and 15 minutes. Spinal anesthesia was employed, 50 mg. of procaine hydrochloride being injected.

Fig. 1.—Roentgenograms showing head unengaged and over-riding the symphysis pubis. Note the considerable distance between head and sacral promontory in lateral view.

The abdomen remained distended by the large cyst, and the following day an exploratory laparotomy was performed. A huge ovarian cyst was found filling almost the entire abdominal cavity, and displacing the intestines upward and to the sides. It arose from the left ovary. In the process of removal, the cyst was accidentally ruptured, and a large amount of clear straw-colored fluid escaped into the peritoneal cavity. The right ovary and tube were normal. The uterus was involuted to about the size of a large grapefruit.

The postoperative course was uneventful, and the patient was discharged from the hospital on Aug. 16, 1949.

The pathological report was corpus luteum cyst of pregnancy (18 cm. in diameter).

It is interesting to note that the huge corpus luteum cyst, pressing and displacing the fetus, had little or no effect upon the course of the pregnancy and labor. Apparently, the location of the cyst on the upper surface of the uterine fundus and the presence of an adequate pelvic outlet (two normal pregnancies had been completed previously) favored an uncomplicated delivery.

CASE 10.—*Strangulated corpus luteum cyst with rupture*

J. Y., aged 13, was admitted to the hospital on June 11, 1949, with the chief complaint of abdominal pain. The pain occurred suddenly in the morning and became progressively severer during the day. There was nausea but no vomiting. The bowel habit was unchanged, and no genitourinary disturbance was present. The past history was essentially normal. The menarche occurred at age 12, and the periods had been regular.

Physical examination revealed a well-developed, well-nourished girl with some pain and discomfort. The pulse rate was 88 per minute, respiration rate 16 per minute, blood pressure 120/80 mm. Hg, and temperature 97.8 F. A differential blood count showed 17,500 leucocytes per cubic centimeter, with 3% stab neutrophiles, 53% segmented neutrophiles, 33% lymphocytes, 6% monocytes, and 5% eosinophiles.

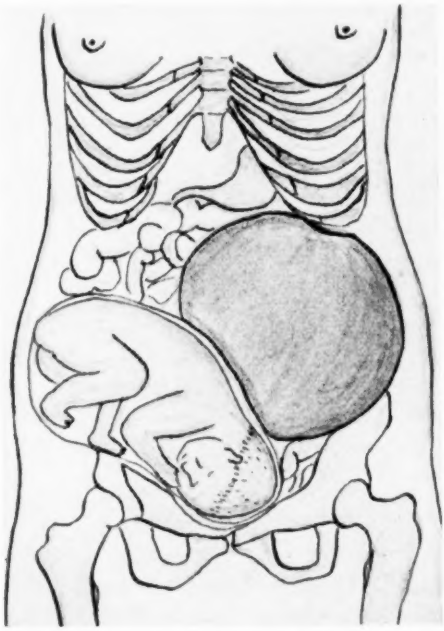


Fig. 2.—Sketch showing giant corpus luteum cyst of pregnancy pushing fetus down into pelvis and displacing it in a transverse position.

The lungs were clear to auscultation, and the heart sounds were normal. The abdomen was flat and nonrigid but tender in the right lower quadrant. No definite mass was palpable.

A presumptive diagnosis of acute appendicitis was made, and the abdomen was entered through a right McBurney incision. Free blood was encountered, and the incision was extended downward and medially. A hemorrhagic ovarian cyst, about the size of a lemon, twisted on its pedicle, was found on the right side. There was a rent in its wall through which dark clotted blood extruded. Clotted blood was also found in the pelvic cul-de-sac. Oophorectomy was performed. The appendix was also removed.

The patient made an uneventful recovery and was discharged on the fifth postoperative day.

The pathological report was strangulated corpus luteum cyst (5 cm. in diameter).

This case is of interest, not only from the standpoint of the patient's age at which the accident occurred but also from the standpoint of the dual lesion present in the ovary. While the predisposing factor was probably a long pedicle with an enlarged

ovary, the inciting cause producing the torsion is not known. The torsion was sufficient to obstruct the venous return but not the arterial supply. Apparently, this produced venous congestion, hemorrhage into the cyst, and finally rupture due to intraluminal pressure increased beyond the tensile strength of the cyst wall.

CASE 20.—*Twisted corpus luteum cyst of pregnancy*

Mrs. R. W., a 21-year-old woman, was admitted to the hospital on March 21, 1951, with the chief complaint of pain in the abdomen of 24 hours' duration. She was three months pregnant. The pain was characterized as aching in nature and localized in the right lower quadrant. It later became very severe, and the patient felt weak and dizzy and vomited.

Examination of the abdomen showed muscle guarding and tenderness over McBurney's point. The peristaltic sounds were active. The hemogram was as follows: erythrocytes 3,860,000 and leucocytes 10,300, with stab neutrophiles 8%, segmented neutrophiles 69%, lymphocytes 21%, and eosinophiles 2%.

A diagnosis of acute appendicitis was made, and the abdomen was entered through a Rockey incision. A moderate amount of straw-colored fluid was encountered. The appendix appeared normal. Examination of the pelvic organs revealed that the right ovary was cystically enlarged to about the size of a large hen egg and twisted upon its pedicle 180 degrees. The uterus was that of a three-month pregnancy. It was soft, boggy, bluish-red, and enlarged. The torsion was reduced, and the cystic ovary removed. The appendix was also extirpated.

The pathological report was corpus luteum cyst of pregnancy with thrombosis of the ovarian artery.

Convalescence was smooth and uncomplicated. Slight vaginal bleeding occurred on the second day, but the products of conception were not expelled. The patient was discharged on the ninth postoperative day.

The folly of making a diagnosis of acute appendicitis for any female without adequate pelvic examination is clearly demonstrated in this case. No doubt it would have been difficult to make a correct diagnosis in this case. The localized pain in the right lower quadrant of the abdomen was naturally in favor of a diagnosis of acute appendicitis, the commonest pathological process occurring in this region. In retrospect, however, the cyst could probably have been palpated and the diagnosis established had a bimanual pelvic examination been performed.

COMMENT

In the normal cycle of ovarian activity, rupture of the Graafian follicle is a physiological process, but rupture of the corpus luteum is pathological and is accompanied by active bleeding. Bleeding may be profuse and exsanguinating. The exact cause of the rupture is unknown, but cystic dilation with increased internal pressure seems to be an underlying factor. The precipitating factor causing the rupture, however, is variable and frequently difficult to determine. Rupture is known to have occurred during sleep,[1] while performing ordinary work,[2] during coitus,[3] during

1. Israel, S. L.: Ovarian Rupture Causing Intraperitoneal Hemorrhage with Report of 10 Cases, Am. J. Obst. & Gynec. **33**:30-38 (Jan.) 1937.

2. (*a*) Weil, A. M.: Ruptured Graafian Follicle and Corpus Luteum with Intra-Abdominal Hemorrhage Simulating Acute Appendicitis and Ruptured Ectopic Pregnancy, Am. J. Obst. & Gynec. **38**: 288-295 (Aug.) 1939. (*b*) Payne, W. R.: Rupture of Corpus Luteum as a Cause of Acute Abdominal Symptoms: Case Reports, Am. J. Obst. & Gynec. **25**:150-151 (Jan.) 1933.

3. Stuckert, H.: Ovarian Hemorrhage, J. A. M. A. **94**:1227-1229 (April 19) 1930. Sloan, W. R.: Rupture of Corpus Luteum of Pregnancy During Coitus Causing Acute Abdomen Followed by Abortion, Brit. J. Med. **2**:26-27 (July 3) 1948. Israel.[1] Weil.[2a] Payne.[2b]

bimanual pelvice examination,[4] and after an abdominal blow.[5] Whatever the inciting cause may be, an increased intraluminal pressure in the corpus luteum, whether produced from within or without, appears to be the underlying factor. In the cases in which rupture occurred during sleep or during the performance of ordinary work, the increased intraluminal pressure may have been produced by excessive transudation and/or hemorrhage within the lumen of the corpus luteum, beyond the tensile strength of its wall. In the series herein reported, rupture occurred during sleep in 4 patients, during coitus in 1, and during the performance of ordinary work in 12.

Corpus luteum cysts and hematomas must occur fairly frequently, though their incidence is entirely unknown. The majority of them, especially the smaller ones, undoubtedly undergo resorption without clinical recognition. Those that come to surgical exploration are primarily those that produce pain in the abdomen, either by cystic dilation of the ovary or by its rupture, with resulting intraperitoneal hemorrhage. Relatively few of the cysts produce menstrual disturbances.

The corpus luteum may rupture at any time during the child-bearing period, from the onset of puberty to the menopause, but the highest incidence is in the young adult, between the ages of 18 and 35. Rupture has been reported to have occurred in the very young. Foisie [6] cites the case of a 12-year-old girl in whom rupture and exsanguinating hemorrhage occurred one month after the menarche. King and Hawes [7] and Pedlow [8] also report a case occurring at this age. In our series, rupture occurred in a 13-year-old girl whose menstrual flow began one year previously. On the other hand, though relatively uncommon, rupture may occur at a period nearing the climacterium. One of the patients herein tabulated was 45 years old when rupture took place. These cases serve to emphasize the necessity of entertaining a diagnosis of ruptured corpus luteum for any female, even at the extremes of the reproductive period.

While follicular rupture, better known as "mittelschmerz," is well recognized, rupture of the corpus luteum, which characteristically occurs during the second half of the menstrual cycle, seems to be poorly appreciated as a clinical entity. Until 1937, in practically all the reported cases in the literature the condition was misdiagnosed preoperatively either as acute appendicitis or as ectopic pregnancy. Only recently have there been an appreciable number of cases with the correct diagnosis.

The sudden onset of symptoms of intraperitoneal hemorrhage in any female of child-bearing age during the second half of the menstrual cycle should lead the examiner to suspect rupture of the corpus luteum.[9] The typical sign of intraperi-

4. Greenhill, J. P.: Ruptured Corpus Luteum Cyst and Unruptured Hematosalpinx in a Nulliparous Woman, Am. J. Obst. & Gynec. **19**:423-424, 1930. Pratt, J. P.: Mild Symptoms from Rupture of Follicle Cyst or Corpus Luteum, Am. J. Obst. & Gynec. **27**:816-824 (June) 1934.

5. Christopher, F.: Hemoperitoneum from Traumatic Rupture of Corpus Lutuem, J. A. M. A. **93**:4556 (Aug. 10) 1929.

6. Foisie, P. S.: Hemorrhage from a Ruptured Corpus Luteum: Report of Case, New England J. Med. **227**:45-46 (July 9) 1942.

7. King, G. C., and Hawes, C. H.: Ruptured Ovarian Cyst in Childhood: Report of a Case in 12-Year-Old Girl, New England J. Med. **215**:576-577 (Sept. 24) 1936.

8. Pedlow, E. B.: Massive Intraperitoneal Hemorrhage Caused by Rupture of Hemorrhagic Corpus Luteum, Ohio M. J. **43**:168-169 (Feb.) 1947.

9. Taniguchi, T., and Kilkenny, G. S.: Rupture of Corpus Luteum with Production of Hemoperitoneum, J. A. M. A. **147**:1420-1424 (Dec. 8) 1951.

toneal hemorrhage—soft, flat, nonrigid but tender abdomen with rebound tenderness—is fairly distinct from those of peritonitis.

During pregnancy, rupture of the corpus luteum is reported to be infrequent. Rosenfeld,[10] in his review of the literature in 1950, found only one case and added one of his own. In the series herein reported, there are three. If the rupture occurs during pregnancy, it usually takes place during the first trimester. Undoubtedly, such an ovarian rupture with resulting intraperitoneal hemorrhage at this early period of gestation would be invariably misdiagnosed as ruptured ectopic pregnancy.

In the surgical treatment of ruptured corpus luteum cysts or hematomas, as much of the ovarian tissue should be preserved as possible. Bleeding can usually be controlled with over-and-over atraumatic absorbable (gut) sutures. Oophorectomy is to be performed only if bleeding is uncontrollable. This is especially true during the early months of pregnancy, for it is generally believed that during this period the corpus luteum is necessary for the proper maintenance of gestation. Yet reports of removal of the corpus luteum without the interruption of pregnancy, even in the first month of pregnancy, are seen. In the four cases of pregnancy herein reported, abortion resulted in one, following the removal of the corpus luteum.

In the later months of gestation, a corpus luteum cyst may cause dystocia and occasionally obstruct labor if it is incarcerated in the pelvis. This may necessitate the performance of Caesarean section to effect delivery of the baby. Usually, however, the cyst is pushed out of the pelvis with the growth of the uterus and rarely produces obstruction to labor.

On very rare occasions, a corpus luteum cyst may enlarge to huge proportions and thus necessitate its surgical removal, as in the case herein presented. Most of the cysts do not grow larger than 5 to 6 cm. in diameter.[11] Reports of cysts reaching larger sizes have occasionally appeared in the literature. Kaufmann[12] mentions a cyst "the size of a child's head." A cyst 11 cm. in diameter that developed in a 34-year-old nonpregnant woman is described by Wheelon and Wilson.[13]

Complications resulting from torsion of the pedicle of the corpus luteum cyst are not frequent but are by no means rare. Hardt and Seed[14] found six cases of torsion in a 25-year survey at the Cook County Hospital. Nucci[15] found two cases at the Elizabeth Magee Hospital over a period of 12 years, during which time 32,287 cases of pregnancies were seen. Probably, the most important predisposing factor in the causation of the torsion is a moderately enlarged cyst with a long redundant pedicle. Changes in the size of the uterus with pregnancy, growth of tumors, and alteration in the intra-abdominal pressure may be inciting factors. The pathological changes that occur in the ovary incident to torsion of its pedicle depends upon the degree of vascular impairment. A moderate twist may be sufficient to obstruct the venous return

10. Rosenfeld, S. S.: Rupture of a Hemorrhagic Corpus Luteum of Pregnancy with Spontaneous Delivery at Term, New York J. Med. **50**:1129-1130 (May) 1950.

11. Anderson, W. A. D.: Pathology, St. Louis, C. V. Mosby Company, 1948, p. 1112.

12. Kaufmann, E., cited by Wheelon and Wilson, J. A. M. A. **112**:2411 (June 10) 1949.

13. Wheelon, H., and Wilson, G.: Corpus Luteum Cystoma, J. A. M. A. **112**:2411 (June 10) 1939.

14. Hardt, H. G., Jr., and Seed, L.: The Diagnosis of Torsion of the Pedicle of an Ovarian Cyst, Am. J. Surg. **56**:598-602 (June) 1942.

15. Nucci, C. R.: Ovarian Cysts Complicating Pregnancy, Pennsylvania M. J. **45**:1059-1065 (July) 1942.

but not the arterial supply. This produces venous congestion and possibly hemorrhage into the cyst. Progressive hemorrhage in the cyst may lead to rupture of its wall and result in hemoperitoneum, as in the case herein presented. When torsion is marked, obstruction of the arterial supply occurs and gangrene of the ovary ensues.

SUMMARY AND CONCLUSIONS

Twenty cases of surgical emergencies resulting from corpus luteum cysts and hematomas are reviewed. In 16 of them the emergencies were due to rupture resulting in hemoperitoneum and two to strangulation by torsion of the ovarian pedicle. In one the cyst produced an obstruction to labor, and in one surgical intervention was required because of marked enlargement of the cyst.

Rupture may occur during sleep, during coitus, or during the performance of ordinary work. All the emergencies brought about by rupture occur during the second half of the menstrual cycle. The highest incidence of rupture is between the ages of 18 and 35.

In most of the cases the condition is misdiagnosed and the cases parade under false headings such as acute appendicitis and/or ectopic pregnancy. The sudden onset of symptoms of intraperitoneal hemorrhage in any female of child-bearing age during the second half of the menstrual cycle should lead the examiner to suspect rupture of the corpus luteum.

While it is readily agreed that many innocent corpora lutea suffer unnecessary surgical abuses, it must be remembered that this generally innocuous organ may in certain circumstances undergo pathological changes necessitating the utmost in diagnostic acumen and immediate surgical intervention.

Case Reports

CHOLELITHIASIS CAUSING BLOOD IN THE STOOLS

A Case of Massive Gastrointestinal Hemorrhage Due to a Gallstone

FRANK H. RIDGLEY, M.D.
WEST CHESTER, PA.

HEMORRHAGE into the gall bladder was first reported in 1892,[1] but textbooks on surgery, medicine, and differential diagnosis do not list cholelithiasis and diseased gall bladders as a cause of blood in the stool. In 1946 Hudson and Johnson [2] reported that 13% of 100 patients proved at operation to have cholelithiasis had varying amounts of blood in the stool preoperatively. A review of the literature to 1948 by Christopher and Savage [3] revealed 28 cases of massive hemorrhage from the gall bladder exclusive of direct trauma.

All authors point out the significance of sclerotic changes in the wall of the gall bladder which by themselves or in combination with stones can produce bleeding that may manifest itself as melena, hematemesis, or rupture of the gall bladder.

A large stone in the neck of the gall bladder may erode the cystic artery, causing an exsanguinating hemorrhage first recognizable from a massive bloody bowel movement. The history and the operative treatment in such a case are summarized.

REPORT OF A CASE

On Jan. 20, 1951, a 61-year-old physician had a sudden attack of severe epigastric pain lasting a few hours. He was well until January 24, having had normally colored stools and no pain. A brief episode of pain in the epigastrium left him with no discomfort. On January 26 a severe attack necessitated unusual amounts of narcosis for relief. There were signs of acute pancreatitis, which diagnosis was fortified by the finding of a serum amylase level of 497 mg. per 100 cc. (normal, 80 to 180 mg.). At this time the red blood cell count was 5,000,000 and the hemoglobin level 14 gm. per 100 cc. By the third day of hospitalization the patient had become rapidly more comfortable, and the abdomen had become soft and much less tender.

The patient again had epigastric pain and a sudden desire to defecate, which resulted in an unusually copious amount of mixed tarry stool and bright red blood. After stabilization of the blood pressure, exploratory laparotomy revealed no fluid or blood in the peritoneal cavity although blood could be seen in the entire intestinal tract. The pancreas was intact but was swollen and hard with edema that hid the common duct and the cystic duct. The distended gall bladder was opened and evacuated of clots and large stones. When the stone at the cystic duct was removed, blood welled into the wound; the bleeding was controlled by a finger in the foramen of Winslow. The critical condition of the patient and the vague anatomy of the cystic duct region forced us to be satisfied with control of the hemorrhage with gelfoam® and gauze in the gall bladder and rapid closure of the abdomen.

Assistant Surgeon, Chester County Hospital.

1. Fiessinger, N.; Bergeret, A., and Leveuf, J.: Hemocholecysts, Rev. Gastroenterol. **5**:383 (Dec.) 1938.

2. Hudson, P. B., and Johnson, P. P.: Hemorrhage from Gall Bladder, New England J. Med. **234**:438 (March 28) 1946.

3. Christopher, F., and Savage, J. L.: Apoplexy of the Gall Bladder, Surgery **24**:864 (Nov.) 1948.

The postoperative course was uneventful, and the packing had been removed by the 16th postoperative day. On the 20th postoperative day the stab wound broke open and bled copiously, leaving the patient in shock. After stabilization of blood pressure, the second entry was made through a subcostal incision in order to explore the stab wound. There was very little edema, and the pancreas was fairly soft and not significantly enlarged. The gall bladder was dissected out from the fundus toward the cystic duct, while bleeding was again controlled by pressure on the hepatic artery. The blood was ultimately found to be spurting from the cystic artery into the lumen of the cystic duct. The artery was doubly ligated and closure was performed routinely with drainage. The postoperative course was uneventful.

SUMMARY

Attention is called to the part played by diseased gall bladders with or without cholelithiasis as a cause of unexplained secondary anemia, hematemesis, melena, or hemorrhage. A case of gastrointestinal hemorrhage from erosion of the cystic artery by a gallstone is presented.

CONGENITAL INTRATHORACIC ANEURYSM OF THE VERTEBRAL ARTERY

WILLIAM H. MULLER Jr., M.D.
DAVID BOODY, M.D.
AND
WILLIAM P. LONGMIRE Jr., M.D.
LOS ANGELES

THE PURPOSE of this communication is to report successful surgical excision of a congenital intrathoracic aneurysm of the vertebral artery. Aneurysms of this vessel, while infrequent, are oftenest found in the third or intracranial portion of the vessel.[1] A review of the literature failed to uncover a report of a case of congenital aneurysm involving the intrathoracic portion of the vertebral artery. In view of the apparent rarity of the anomaly, it was felt that it might be worth while to report our case.

REPORT OF A CASE

The patient was a 16-year-old white youth who at the age of 4 years was found to have a continuous murmur in the left upper aspect of the chest and the left side of the neck. At that time a diagnosis of arteriovenous aneurysm arising from the left subclavian artery was made. The patient's development was entirely normal, and he had no symptoms which could be attributed to an aneurysm or to an arteriovenous fistula of this region. One year prior to his admission he was hospitalized because of severe headaches which occurred after an injury to the right side of the forehead while he was playing football. At this time the murmur in his chest was again noted, and surgical treatment was advised.

Physical Examination.—The patient was well developed and well nourished and did not appear chronically ill. The only abnormal physical findings were in the chest and neck. One could hear a continuous murmur with systolic accentuation which was maximal in the first and second intercostal spaces 2 to 3 cm. to the left of the sternum and over the left anterolateral aspect of the neck. One also could hear this murmur posteriorly in the neck and the left side of the chest. The murmur could not be made to disappear by obliterating the carotid artery in the neck. There was no enlargement of any of the veins in the neck or left upper half of the body. The blood pressure was 124/80. The red blood cell count was 4,500,000 and the hemoglobin level 13.5 gm. The white blood cell count was 7,600, with an essentially normal differential count. Electrocardiographic examination showed a normal tracing.

From the Department of Surgery, University of California Medical School, Los Angeles, and the Section on Cardiovascular Surgery at the Los Angeles County Harbor General Hospital, Torrance, Calif.

1. Spath, F.: Über Die Verletzung und das Aneurysma der Arteria vertebralis, Zentralbl. Chir. **65**:2257 (Oct.) 1938. Kuttner, H.: Die Operation des Vertebralisaneurysmas und ihre Erleichterung durch lebende Tamponade, Zentralbl. Chir. **57**:1025 (April) 1930. Callander, C. L.: Study of Arteriovenous Fistula with an Analysis of 447 Cases, Ann. Surg. **71**:428 (April) 1920. Bassoe, P.: Aneurysm of the Vertebral Artery, Arch. Neurol. & Psychiat. **42**:127 (July) 1939. Rigdon, R. H., and Allen, C.: Aneurysms of the Vertebral Arteries: A Consideration of Their Etiology, J. Lab. & Clin. Med. **29**:28 (Jan.) 1944. Dunn, A. D.: A Case of Aneurysm of the Vertebral Artery, Nebraska M. J. **12**:229 (June) 1927.

Roentgenographic Examination.—The lordotic apical view of the chest revealed a sharply delineated mass density in the upper medial border of the left apex. The transverse processes of the proximal ribs were not well demonstrated in this view. The planogram visualized the mass at the 9 and 10 cm. level and showed some erosion of the seventh cervical vertebral body. The angiocardiogram revealed an opacity which filled the area of the apex enclosed by the first rib (Fig. 1). A diagnosis of aneurysm of the left subclavian artery was made.

Operation.—On Aug. 6, 1951, exploration was carried out through an anterolateral incision in the third left intercostal space, and one could see that the left subclavian artery was approximately 1.5 to 2 cm. in diameter. One could also see and palpate a pulsating mass in the apical portion of the chest at the level of the first rib. The sternum was split in the midline, and the

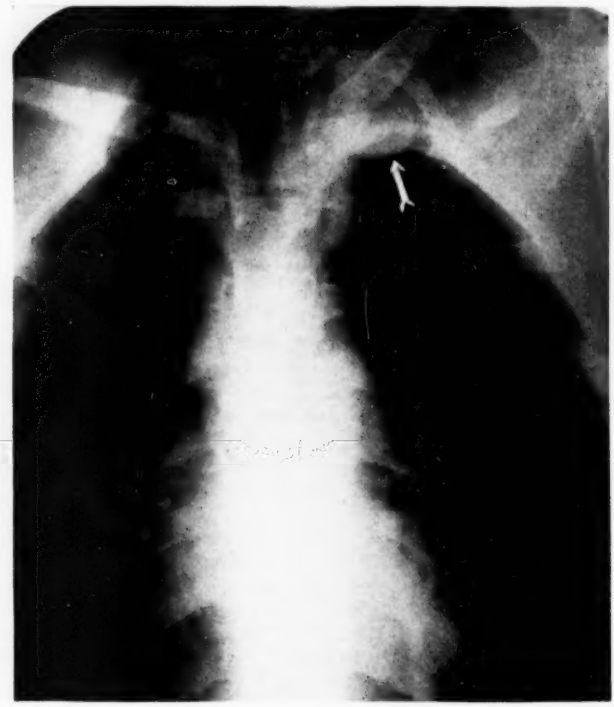


Fig. 1.—Angiocardiogram showing aneurysm in apical region of the left side of the chest.

incision was carried over the course of the left clavicle for approximately 6 cm. The clavicle was not divided. The mediastinal pleura was dissected away from the subclavian artery, and it was found that the mass ceased to pulsate when the subclavian artery was occluded. It was noted that a subclavian artery of normal size arose from the larger first portion and extended into the left upper extremity. Since the aneurysm arose from the first branch of the subclavian artery, it was decided that this was an aneurysm of the left vertebral artery. The mass was dissected free from the first rib. Three arteries joined the mass—a large artery which extended into the neck, the first portion of the subclavian artery, and the terminal vertebral artery which entered the foramen in the transverse process of the sixth cervical vertebra. These three arteries were occluded by means of Potts ductus clamps, and the aneurysm was excised. The ends of these vessels were oversewn with continuous 00000 arterial sutures. It was noted that a large area of erosion approximately 1.5 to 2 cm. in diameter was present at the point of entry of the aneurysm in the

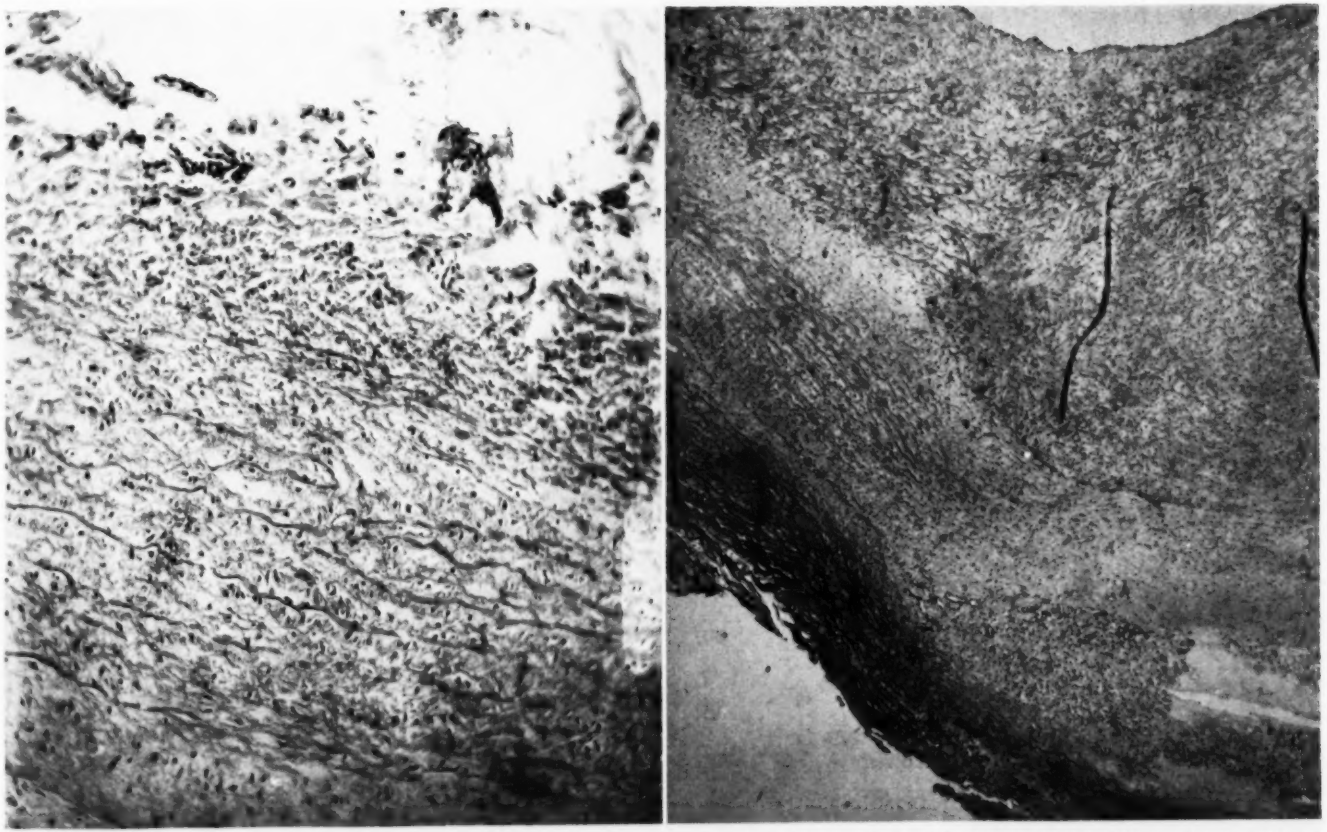


Fig. 2.—Photomicrographs of wall of aneurysm showing extensive mucinous degeneration of the media with focal subendothelial fibrous tissue proliferation.

cervical vertebra. It was noted also that what was thought to be the sixth cervical nerve root, which was closely adherent to the aneurysm, had been divided in removal of the aneurysm, and thus the ends were reapproximated. The patient's postoperative course was uneventful except that he had Horner's syndrome on the left and weakness of the left arm due to division of the nerve root. The murmur was no longer present.

Histologic study of the aneurysm showed extensive mucinous degeneration of the media, with focal subendothelial fibrous tissue proliferation (Fig. 2).

COMMENT

We felt there was little question that this was a congenital aneurysm because it did not have the gross appearance of a syphilitic or mycotic aneurysm, a murmur had been discovered when the patient was 4 years old, and on histologic examination no other etiologic factor could be determined.

Although this aneurysm, which was known to have been present since childhood, had caused no symptoms, surgical treatment seemed advisable because of the size of the aneurysm, evidence of erosion of the cervical vertebra, and the tendency of congenital intracranial aneurysms of the vertebral artery to rupture spontaneously in later life.

Shumacker [2] advocates an incision through the bed of the resected clavicle for exposing arteriovenous fistulae of the subclavian and vertebral arteries. However, he used a sternum-splitting approach for excision of an aneurysm of the innominate artery.[3] Elkin and Harris [4] used an incision through the sternal and clavicular heads of the sternocleidomastoid muscle in treating arteriovenous fistulae of the first portion of the vertebral artery. We began the exploration in this case through an anterolateral transpleural approach in the third intercostal space in order first to secure the subclavian artery at its origin. The sternum was then split to facilitate exposure of the distal end of the aneurysm. In this case excision of the aneurysm was the procedure of choice since excision of an aneurysm is desired when feasible and since the first portion of the vertebral artery can be divided with impunity.

2. Shumacker, H. B., Jr.: Operative Exposure of Blood Vessels in Superior Anterior Mediastinum, Ann. Surg. **127**:464 (March) 1948.

3. Shumacker, H. B., Jr.: Surgical Cure of Innominate Aneurysm: Report of a Case with Comments on the Applicability of Surgical Measures, Surgery **22**:729 (Nov.) 1947.

4. Elkin, D., and Harris, M. H.: Arteriovenous Aneurysm of the Vertebral Vessels: Report of 10 Cases, Ann. Surg. **124**:934 (Nov.) 1946.

LEIOMYOMA OF THE COMMON BILE DUCT

HENRY ARCHAMBAULT, M.D.
AND
RENE ARCHAMBAULT, M.D.
DETROIT

THE MOST comprehensive review of the literature on benign tumors of the common bile duct was written by Chu [1] in 1950. In this review he lists 24 papillomas and polyps, 18 adenomas, 3 fibromas, 3 neuromas, 2 granulomas, 1 melanoma, and 1 carcinoid. To this list we should like to add the report of a case of leiomyoma of the interior pancreatic portion of the common bile duct. We have been unable to find any previous reviews dealing with benign or malignant neoplasms of the muscular wall of the choledochus.

REPORT OF CASE

History.—The patient, a 31-year-old woman, was admitted to Providence Hospital, Detroit, on March 2, 1950, with a history of episodes of nausea and vomiting and itching of one year's duration. Jaundice, which had not been too pronounced because of the patient's swarthy complexion, had become increasingly more marked. Itching was very troublesome. The patient stated that she had had dull and persistent pain in the epigastrium and right upper abdominal quadrant. Her appetite had been only fair, and she had lost 15 lb. (6.8 kg.) in weight. We had noticed that her urine was dark and her stools light.

Her past history revealed two significant facts: (1) an episode of right upper quadrant pain radiating to the back, with nausea and vomiting, at Thanksgiving time in 1949; (2) an admission to this hospital one month prior to the present admission with a diagnosis of catarrhal jaundice.

Physical Examination.—Examination showed a markedly jaundiced patient with multiple scratch marks and ecchymosis of the right posterior lateral thigh. The abdomen was moderately distended, and the liver could be felt 3 fingerbreadths below the right costal margin.

Laboratory Data.—The x-ray reports indicated nonvisualization of the gall bladder dye. This could be interpreted either as a gall bladder that failed to fill or as a lack of dye concentration due to liver disease. Stools were reported by the nurse to be clay-colored. Subsequent examinations showed stools to be of a greenish-brown color. Laboratory findings, though suggestive of obstruction, were inconclusive.

Operative Procedure.—An exploratory operation was made on March 30, 1950. With the patient under general anesthesia, a right transverse incision was made and was subsequently extended in a vertical manner up to the xiphoid process. Exploration of the abdomen revealed nothing significant except for presence of a mass in the right upper quadrant. The small bowel was displaced medially, and the peritoneum, along the lateral edge of the second portion of the duodenum, was incised to permit mobilization of the duodenum and pancreas, as done in the Kocher maneuver. The common bile duct was carefully isolated from the portal vein and the hepatic artery by retracting both these structures with an umbilical tape. The common bile duct was divided above the tumor and the line of incision carried into the pancreatic tissue just beyond the mass. This necessitated the division and ligation of the duct of Santorini but left the duct of Wirsung intact. The end of the common bile duct was anastomosed to the

From the Surgical Service, Providence Hospital, Detroit.

1. Chu, P. T.: Benign Neoplasms of the Extrahepatic Biliary Ducts, Arch. Path. **50**:84 (July) 1950.

apex of the jejunal loop with use of a T-tube, as shown in Figure 1. The abdomen was closed in the usual fashion after a Penrose drain was placed in the Morison pouch.

Postoperative Course.—The patient made a good postoperative recovery. The pruritus disappeared almost immediately after surgery, and the jaundice gradually faded away. During the first few months following operation, the patient experienced vague upper abdominal

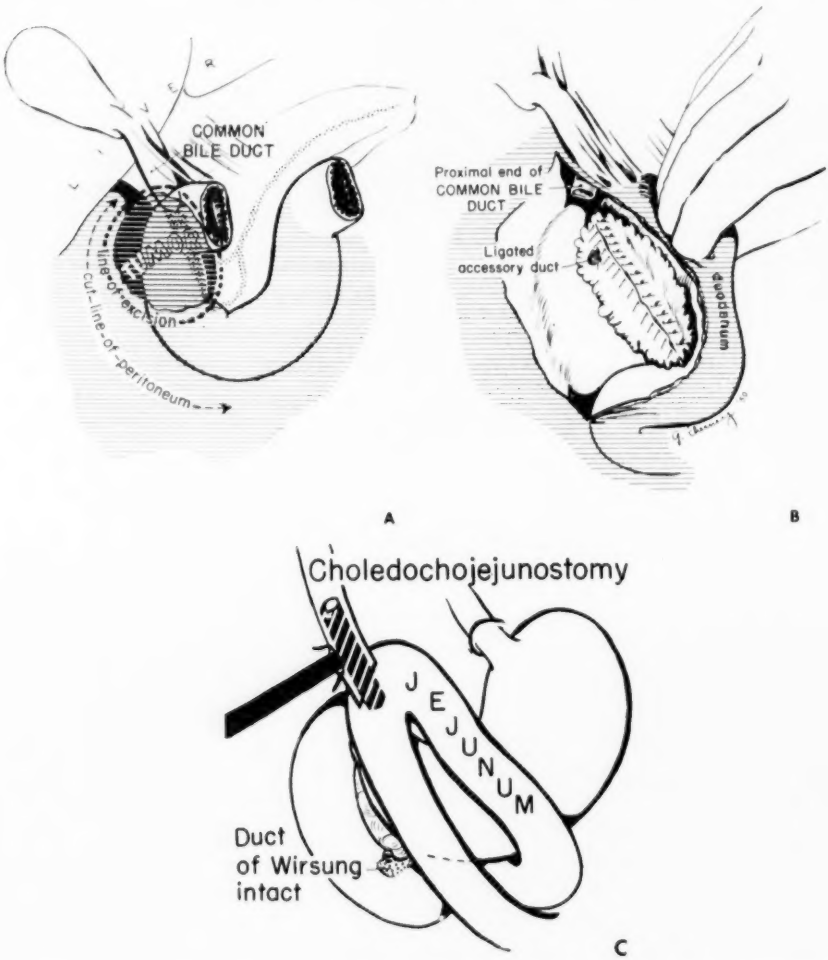


Fig. 1.—*A*, location and extent of lesion with circumventing line of dashes representing line of excision; *B*, maneuver described by Kocher and sutured pancreatic tissue; *C*, choledochojejunostomy with T-tube in position.

discomfort. At the present time (Jan. 28, 1952) she feels perfectly well except for a feeling of emptiness, which is remedied by food intake.

Pathological Findings.—Photographs show the macroscopic and microscopic nature of the tumor. The tumor was interpreted by Drs. A. P. Stout and R. Lattes, of the surgical department of Columbia University, as a leiomyoma of the common bile duct.

Fig. 2.—Bisected tumor with opened proximal end of common bile duct occupying center of mass. *A*, intraluminal projection of tumor. In floor of common bile duct is bulging mass consisting of myomatous tissue.

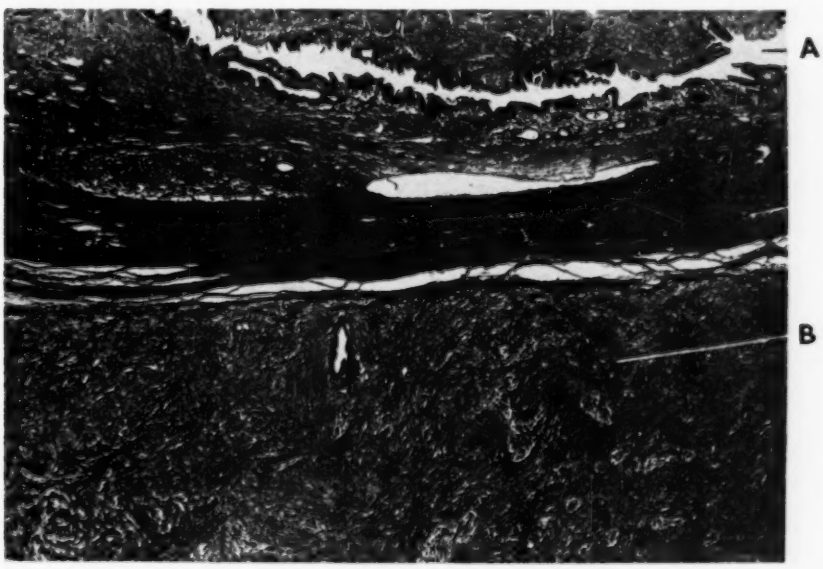


Fig. 3.—Tumor tissue: *A*, lumen; *B*, leiomyoma. × 155.

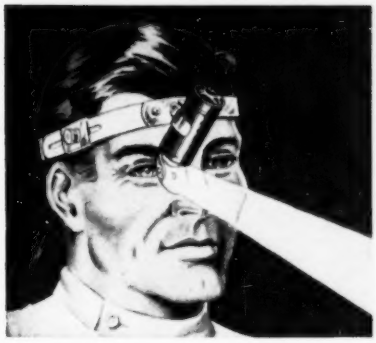
COMMENT

The fluctuation of the color of the stools, that is, from clay to greenish-brown stools, is obviously due to the intermittency of the obstruction of the common duct. This would also explain the fluctuation found in the chemical tests.

On repeated x-ray examinations on May 14, 1951 (14 months after operation) by Dr. W. I. Irwin, of the department of radiology of Providence Hospital, barium could be seen to enter the biliary radicles. Apparently this did not have any deleterious effects, since the patient is free of all symptoms at the present time. We believe that stomach chyme may enter biliary radicles after such procedure but that the intrabiliary pressure of the bile is sufficient to flush out any of the food detritus that may enter the duct system.

The probability of a benign tumor of the common bile duct, though of extremely rare occurrence, should be borne in mind in all cases in which symptoms of biliary obstruction are present. In this case, as in 11 cases reviewed by Chu,[1] surgical excision was possible.

MECHANICAL PERFECTION TO AID SURGICAL SKILL



Perfect illumination for all body cavities, throat, nose, ear, larynx, oral surgery, dental surgery, brain surgery, eye surgery, gynecology, bronchoscopy, fenestration, proctoscopy.

GOOD-LITE

THE PHYSICIANS UNIVERSAL HEADLIGHT

Constructed with finest scientific craftsmanship to give you an instrument of enduring quality . . .

Good-Lite is one of the finest, most brilliant headlights ever constructed. You have 750 foot candles directed exactly where you want it and to a depth you desire. Good-Lite is completely adjustable so that it will fit all doctors. It may be used over one eye for deep, narrow cavities, or between the eyes for shallow cavity work, or at the side for oblique illumination. May be readily adjusted for parallel, divergent or convergent rays. Removal of mirror permits use as direct headlight.

GOOD-LITE UNIT INCLUDES

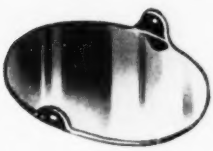
Good-Lite Parallel Headlight
Two mirrors
Extra long life bulbs
Variable 15 watt transformer
Molded shock-proof rubber connections
White acetate plastic headband, leather or fiber, (form-fitting)

Sold at leading medical and dental supply houses— or use coupon.

GOOD-LITE CO.
7638 MADISON STREET
FOREST PARK, ILLINOIS

COMPLETE WITH TWO MIRRORS

. . . Twin Mirrors Are Readily Interchangeable.



PLAIN MIRROR

PEEP HOLE MIRROR

1. PLAIN MIRROR—For shallow cavities such as throat, eye, vagina, fenestration and other surface work.
2. PEEP HOLE MIRROR—Center of beam light for deep cavities such as nose, larynx, ear, bronchoscopy. Has protective shield, open aperture—no glass to cloud or blur.
3. DIRECT LIGHT for surface surgery by simply removing mirror.

GOOD-LITE CO., DEPT. S
7638 MADISON STREET, FOREST PARK, ILLINOIS

☐ Please send me illustrated booklet describing in detail the Good-Lite Parallel Ray Headlight.

☐ Please send me_____Good-Lite Parallel Ray Headlight units, complete with extra long life bulb, variable 15 watt transformer, molded shock-proof connections, @ $32.50 ea.

☐ White acetate plastic, ☐ leather, or ☐ fiber form-fitting headband

Name_____

Address_____

City_____ Zone_____ State_____

"Pressoplast"

Natural or Flesh Colored

Adhesive Cotton E-L-A-S-T-I-C Bandage

"Contura" —**BANDAGE**

skin protecting medicated

Write for Literature and Reprints

MFRS. OF ELASTIC BANDAGES AND DRESSINGS

Medical Fabrics Co., Inc.

10 Mill Street Paterson 1, N. J.

Child Health

Bad Habits in Good Babies. Herman M. Jahr. 16 pages. 15 cents.

What Does Your Baby Put in His Mouth? Chevalier Jackson and Chevalier L. Jackson. Tells how to prevent accidents from choking and what to do if they happen. 24 pages. 15 cents.

Keeping Your Baby Well. 22 pages. 15 cents.

The Case of the Crying Baby. Herman M. Jahr. 4 pages. 15 cents.

What to Do About Thumb Sucking. William I. Fishbein. 6 pages. 15 cents.

Lefthandedness. Paul Popenoe. 8 pages. 15 cents.

Adoption. W. Allison Davis and Theo Carlson. An understanding discussion of the best ways to adopt children and rear them. 12 pages. 15 cents.

Protecting Your Child from Allergy. William Gayle Roberts. 8 pages. 15 cents.

The Facts About Sex. Audrey McKeever. 16 pages. 15 cents.

Please remit with order

AMERICAN MEDICAL ASSOCIATION

535 N. Dearborn St. • Chicago 10

Your "experience exchange" in the field of Skin Diseases and Syphilis—A valuable guide in your Practice—

A. M. A. Archives of DERMATOLOGY and SYPHILOLOGY

SIGNIFICANT DEVELOPMENTS reported monthly to the specialist and the physician in general practice. From hospitals, clinics and government treatment centers here and abroad, A. M. A. Archives of DERMATOLOGY and SYPHILOLOGY gathers news of current trends in treatment and diagnosis, group case studies, clinical notes and comments on cutaneous conditions and syphilis.

Well illustrated.

Ably edited.

AMERICAN MEDICAL ASSOCIATION

535 N. Dearborn St., Chicago 10, Illinois.

Please Begin My Subscription to A. M. A. Archives of DERMATOLOGY and SYPHILOLOGY with the Next Issue.

.....M.D.

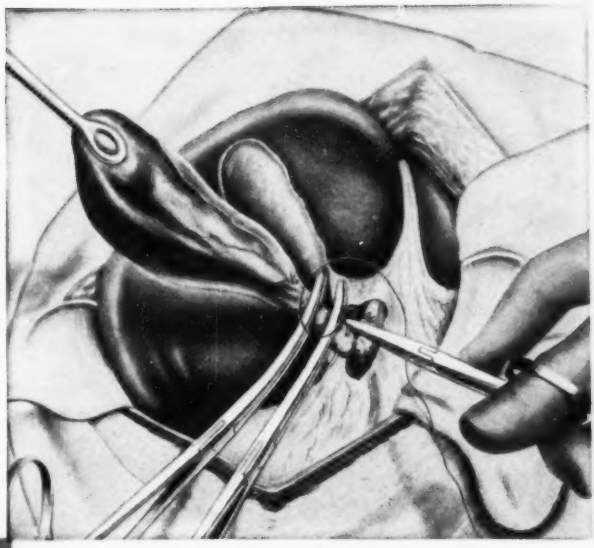
.....STREET

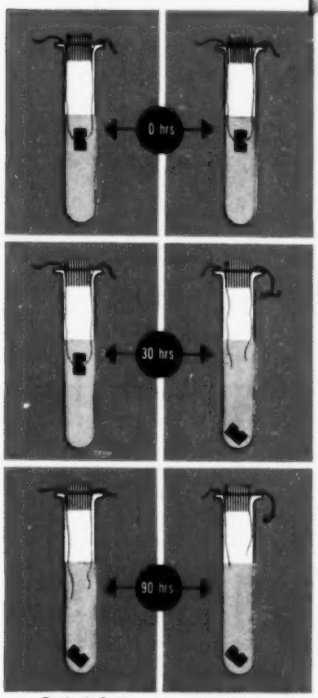
.....CITY AND STATE

$12.00 YEARLY

$13.50 FOREIGN $12.40 CANADIAN

For this critical ligation "timed-absorption" surgical gut sutures will not digest prematurely





Davis & Geck "timed-absorption" sutures

non timed-absorption chromic sutures

In ligating the cystic duct, the skill of the surgeon must be supported by a dependable ligature which will not digest prematurely. By an exclusive improved process, D & G "timed-absorption" surgical gut is accurately tanned in *graded degrees* from the outer surface inward to assure a logical digestion rate. Maximum resistance to digestion is assured during *the critical first 4 days* when there is least fibrosis. As fibrosis develops and the need for artificial support lessens, the rate of timed-absorption increases.

90 hours vs. 30 hours

Comparison of D & G "timed-absorption" medium chromic surgical gut suture, size O, with non timed-absorption medium chromic surgical gut suture, size O. Weights are suspended from each in trypsin solution. The weight is held suspended by "timed-absorption" surgical gut up to 90 hours. The non timed-absorption chromic surgical gut suture has begun to digest and breaks under the strain of the weight by 30 hours. *(In human tissue all chromic sutures are digested more slowly, but the ratio between the two types remains the same.)*

D & G surgical gut sutures have a special matte finish so that knots hold securely.

Davis & Geck, Inc.

A UNIT OF AMERICAN Cyanamid COMPANY

57 Willoughby St. Brooklyn 1, N. Y.

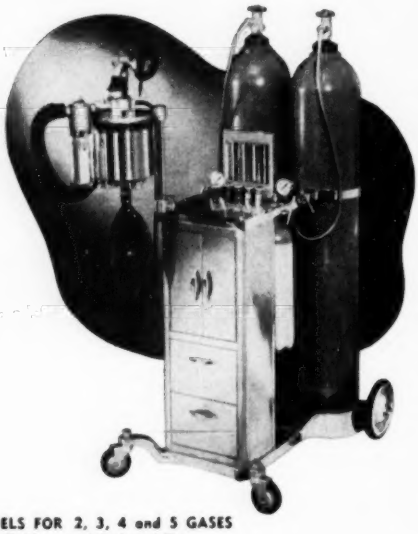
Surgeons Agree on D & G

The E & J ANESTHESIOR

A New Instrument for All Usual and Special Forms of Anesthetic Gas Administration

with these new features:

- **UNINTERRUPTED ANESTHESIA during Soda-lime replacement.**
- **CO_2 ABSORPTION ADJUSTABLE.**
- **NO PIPES OR METAL TUBES to loosen or leak. Gas lines drilled in cast Table.**
- **EXACT CONTROL WITH ALL-METAL FLOW VALVES replaceable as a unit.**
- **ONE-PIECE FLOWMETER PANEL, easily disconnects merely by loosening two bolts.**



MODELS FOR 2, 3, 4 and 5 GASES
Cabinet and Pedestal Types

The Anesthesior has been developed by E & J scientists and engineers to provide a superior facility for gas anesthesia administration. Its operation is easier and more convenient, its control finer, its maintenance much simpler and its greater versatility a definite contribution to the further refinement of administration techniques.

Write to E & J today for complete Anesthesior data

E & J MANUFACTURING CO.
Glendale 1, California

PAMPHLETS ABOUT Vision

Whom Shall I Consult About My Eyes? F. T. Jung. 8 pages. 10 cents.

Eyes—Right! Audrey McKeever. 14 pages. 15 cents.

How to Save Your Eyes. Cleo Du Bois. 4 pages. 10 cents.

Should Your Child Wear Glasses? J. Robert Burke. 12 pages. 15 cents.

Color Blindness. Dean Farnsworth and Conrad Berens. 2 pages. 10 cents.

New Eyes for Old (Corneal Transplant). Max Fine. 10 pages. 20 cents.

Glaucoma. Arthur A. Knapp. 12 pages. 15 cents.

Cataract. Abram B. Bruner. 12 pages. 15 cents.

Visual Efficiency. Henry A. Imus. 8 pages. 10 cents.

Please remit with order

AMERICAN MEDICAL ASSN.
535 N. Dearborn St. • Chicago 10

CLINICAL PHOTOGRAPHY

AN ESTABLISHED SERVICE TO THE MEDICAL PROFESSION

• SURGICAL DRAWINGS • PHOTOMICROGRAPHY • COPIES FROM BOOKS
• COLOR AND BLACK AND WHITE • LANTERN SLIDES • MOULAGES
• PHOTOGRAPHS OF PATIENTS • MOTION PICTURES • X-RAY PRINTS
• PROMPT ATTENTION TO MAIL ORDERS

MARTIN HAGGETT

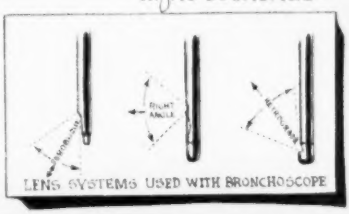
220 WEST 42nd STREET N. Y. C. 18 WIsconsin 7-2602

THE *Broyles* BRONCHOSCOPE

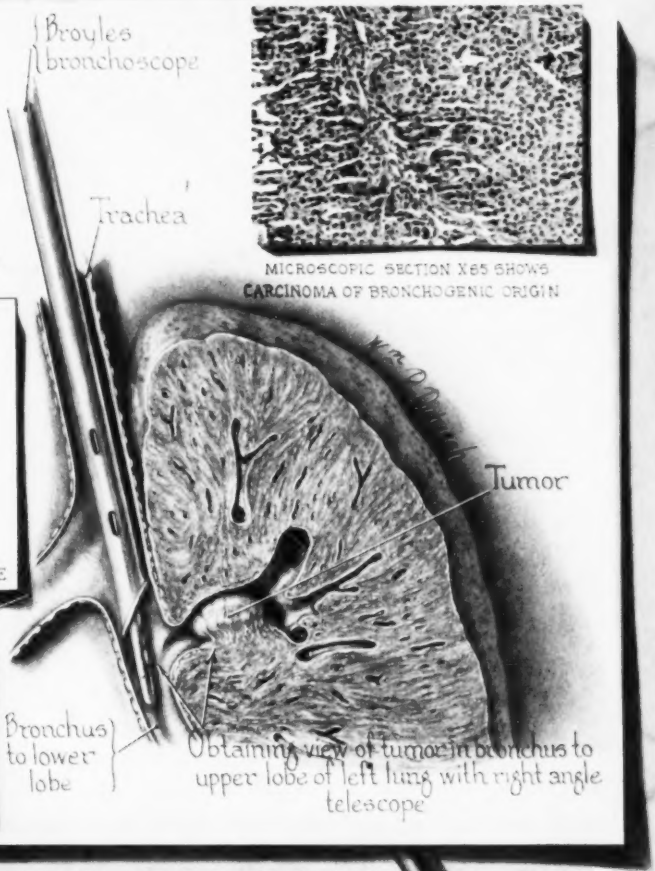
XRAY INDICATES PATHOLOGY IN UPPER LOBE BUT NOT DIAGNOSTIC OF NEOPLASM

MICROSCOPIC SECTION X85 SHOWS CARCINOMA OF BRONCHOGENIC ORIGIN

VIEW OBTAINED WITH RIGHT ANGLE TELESCOPE



LENS SYSTEMS USED WITH BRONCHOSCOPE


Broyles bronchoscope
Trachea
Tumor
Right bronchus
Bronchus to lower lobe
Obtaining view of tumor in bronchus to upper lobe of left lung with right angle telescope

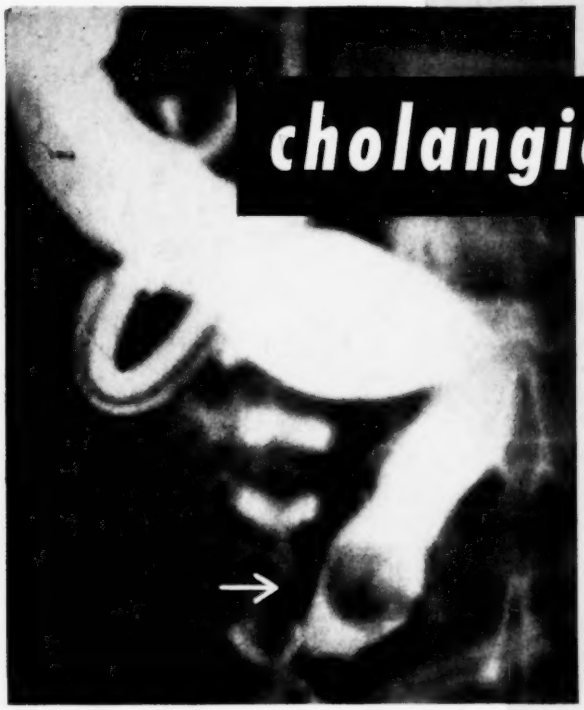
Case of early tumor in bronchus of upper lobe, left lung. X-rays inconclusive. Broyles bronchoscope with right angle lens system disclosed small tumor in left bronchus.

ESTABLISHED IN 1900 BY REINHOLD WAPPLER

FREDERICK J. WALLACE, *President*

American Cystoscope Makers, Inc.

1241 LAFAYETTE AVENUE NEW YORK 59, N. Y.



cholangiography

Cholangiogram with Diodrast 35% showing stone in distal end of common duct. Illustration, courtesy of Dr. J. Buckstein, author of "The Digestive Tract in Roentgenology" (Lippincott, 1948) in which a whole chapter is devoted to this procedure.

Easy Roentgenologic Detection of "the 10 to 18 per cent of stones left behind after common duct exploration"[1]

"Since 1934 we have employed visualizing cholangiograms in all operations on the extrahepatic biliary system. More than 1700 studies have been made and from this experience much information has been obtained. Operative cholangiograms demonstrate congenital aberrations and anatomic displacements of the extrahepatic biliary system; determine patency of the ductal system; note number and position of offending calculi; designate functional status of the sphincter of Oddi; outline fistulous communications; visualize bile reflux into the pancreatic ducts; detect intrusions of neoplasms which impinge on the large bile ducts or originate in the ampulla of Vater; and visualize dilatation, sacculation or diverticular enlargements of the bile ducts themselves. Such exact information permits the surgeon to select the operative procedures best suited to alleviate existing pathologic abnormalities."[2]

1. Byrne, R. V.: Amer. Jour. Surg., 78:514, Oct., 1949.
2. Hicken, N. F., Stevenson, U. L., Franz, B.J., Crowder, Earl: Amer. Jour. Surg., 78:347, Sept., 1949.

Diodrast®

35% SOLUTION

BRAND OF IODOPYRACET INJECTION

For Clear Visualization of the Biliary Tract

Also Urinary Tract, Arteries, Veins

Ampuls of 10, 20 and 30 cc.

Simplified Technic

For a detailed discussion of a simple fractional method for cholangiography postoperatively or operatively write for illustrated pamphlet.

Winthrop-Stearns INC.

NEW YORK 18, N. Y. WINDSOR, ONT.

Diodrast, trademark reg. U. S. & Canada